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THE HUMAN SKELETON

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THE HUMAN SKELETON

A Manual for Archaeologists

by

J. E. Anderson

Illustrated by Tom Munro

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PREFACE

This Manual of Osteology is designed to assist beginning students in the laboratory study of the human skeleton and to serve as a compact guide book in the field. For more detailed information the references cited should be consulted.

The first eight chapters describe the anatomy of the skeleton; the last ten provide an introduction to osteological analysis. It is hoped that this brief outline of the osteological work of the physical anthropologist will stimulate embryo archaeologists to consider the excavation and study of burials an essential part of the total archaeological picture of a site.

The illustrations, which were made from actual specimens in the Physical Anthropology Laboratory at the University of Toronto, are designed to be simple and instructive without sacrificing accuracy. The interest and skill of the artist, Mr. Munro, is evident in the results. I am very grateful to him.

It is a pleasure to acknowledge the assistance of many colleagues at the University of Toronto who have helped in the preparation of this Manual. Dr. J. C. B. Grant, Professor Emeritus, first stimulated my interest in Physical Anthropology. Dr. J. W. A. Duckworth, Professor of Anatomy, provided facilities for the Laboratory of Physical Anthropology in his department. Through his enthusiasm and experience in teaching osteology to archaeologists, Dr. J. Norman Emerson, Supervisor of Archaeological Studies, encouraged the preparation of this Manual. He was a valuable adviser and guide. Dr. K. O. McCuaig and Dr. D. Gratton critically read parts of the text. Miss Rosalind Murray checked the bibliographies; Miss Margaret Murphy typed many drafts of the chapters; and Miss Diane Pryce prepared the final manuscript.

I am indebted to the National Museum of Canada and its Director, Dr. L. S. Russell, for support, both moral and financial. Dr. Lawrence Oschinsky has kindly read and criticized the manuscript. The assistance and encouragement of Mr. W. E. Taylor in preparing the Manual for publication is particularly appreciated.

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JUNE, 1961
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CHAPTER I

ABOUT BONES

INTRODUCTION

This manual is a guide to the study of the human skeleton and to the information that it conveys about the living individual of which it formed a substantial part.

The illustrations in this book are labelled to conform with the descriptive text and may be used for learning, reviewing, and reference. Although useful, pictures are a poor substitute for the real skeleton, which should be consulted at every stage of the learning process.

Osteology does not consist in memorizing a large body of facts; the skeleton should be approached with an inquisitive mind: The bicipital groove—How did it get its name? What causes it? How deep is it? How wide is it? What forms its limits?

ANATOMICAL TERMINOLOGY

Certain standard terms are used by anatomists in describing the structures of the human body. Before proceeding further, it is essential that a knowledge of these, the "house rules" of the game, be well understood.

In describing the human body, all references are related to what is known as the ANATOMICAL POSITION. That is, we consider the individual to be standing erect, with feet together, eyes facing straight ahead, and hands at the side with palms facing forward.

In a relative sense, all structures closer to the front of the body are termed ANTERIOR; all structures closer to the back of the body are POSTERIOR. For example the chest bone is anterior to the back bone.

SUPERIOR means closer to the head end; INFERIOR means closer to the floor upon which the subject is standing. The skull is superior to the thorax; the pelvis is inferior to the ribs.

The MEDIAN plane divides the body into right and left halves.

MEDIAL means closer to the median plane of the body; LATERAL means further away from it. The thumb is lateral to the little finger; the ribs are medial to the arm.

In describing a limb, DISTAL refers to positions closer to the tips of the fingers or toes; PROXIMAL refers to positions closer to the trunk. The wrist is distal to the forearm; the hip is proximal to the thigh.

In general terms, then, we might say:

ANATOMICAL TERM	COMMON TERM
Anterior	in front of
Posterior	behind
Superior	above
Inferior	below

Remember, again, that we are referring to a person *in the anatomical position.*

The Shape of Bones

To the beginning student confronted with the material from an ossuary excavation, the human skeleton is a bewildering jumble of bone fragments of unlimited variation in size and shape. As the work progresses, however, order begins to come out of chaos, and individual bone fragments appear as old friends whose distinguishing characteristics have become known through familiarity.

Just what sort of characteristics should we look for in identifying bones? Consider, first, variations in shape. Bones have been classified into four groups: tubular, cubical, flat, and irregular.

TUBULAR—Also referred to as *long* bones. Characteristically they have a pipe-like shaft and two capped ends. The shell is made of dense, compact bone; the core, spongy bone.

Look at the large bones of the arms and legs: humerus and femur, radius and ulna, tibia and fibula.

CUBICAL—Also called *short* bones. They [illegible] shaped like irregular cubes. The small bones of the wrist and ankle fall into this category.

Look at the talus and the capitate.

FLAT—Consisting of [illegible] sandwich, the bread represented by dense bone, and the filling by spongy bone.

Look at the sternum, scapula, ribs, and bones of the vault of the skull.

IRREGULAR—Include all which fail to fit any of the three patterns described above.

Look at the pelvic bones, vertebrae, the bones of the facial skeleton.

Markings

The bones of the skeleton bear many markings. The study of these features can be [redacted] dull procedure of memorizing [redacted] multitude of meaningless names, or [redacted] experience as interesting as following the plot of a detective story.

Bones are moulded by the organs with which they are in contact, scarred by the attachment of muscles and ligaments, grooved by vessels and nerves, shaped by body function, and distorted by disease and injury.

From an intelligent and curious study of the skeleton, much can be learned about the individual: sex, stature, build, age, race, disease, diet, and customs. With this goal in mind, [redacted] will now determine the various features present in the skeleton and discuss how they occur. This will be our basic training for reading osteological detective stories.

Muscle Attachments

Muscles are able to move the various parts of the body because their attachments to bone span joints.

1. Muscles may attach to bone by means of FLESHY FIBRES, in which case they leave no scar.

   See the anterior aspect of the femur which, although utilized by many fleshy muscles, remains smooth.

2. Muscles may attach by means of [redacted] thick tough TENDON, in which case a lump will remain to mark the site of contact. These lumps may be called tubercles, tuberosities, trochanters, or processes, depending on their size.

   See the lesser trochanter on the posterior aspect of the proximal end of the femur. The strong tendon of the Psoas muscle attaches here.

3. Some muscles attach by means of [redacted] thin flattened tendon known as an APONEUROSIS. This type of attachment is shown by a linear roughening.

See the linea aspera on the posterior surface of the femur. It is wide because a number of aponeuroses attach along its length.

4. Where a tendon plays over a bony surface, the contact area becomes smooth and grooved.

   See the bicipital groove on the proximal end of the humerus, in which moves the tendon of the biceps muscle.

Ligaments

Ligaments are tough bands or cords of tissue which strengthen and support joints.

They may arise from elevated points.

See the epicondyles of the femur.

Or they may leave pits at the site of their attachment.

See the depression on the head of the femur for a ligament which attaches the femur to the pelvic bone.

Other Markings

Like footprints in the sand, other structures of the body leave their impressions upon bone. Sometimes markings are present on bone at the site of *contact with arteries, nerves, and veins.*

See on the interior of the skull vault, the delicately patterned grooves for the middle meningeal artery.

Holes are present at certain sites where *nerves and vessels pass through bone.*

See the mental foramen on the mandible, which transmits the mental nerve.

Various organs leave the impression of their shape upon the bones with which they are in contact.

See the finger tip fossa within the skull which marks the site of the pituitary gland.

Joint Surfaces

When two bones come in contact with each other, a joint or articulation is formed. They are said to "articulate with" each

other, and the area of contact on each bone is called the articular or joint surface. This surface, which is covered with cartilage during life, normally appears smooth on dried bones.

> *Look* at the ends of long bones and locate the smooth articular areas.

Bones may articulate with each other in a number of ways. These different types of joints will be reflected in the distinctive appearance of certain joint surfaces.

1. Two bones may be stuck together by fibrous tissues.

> *Look* at the jagged, irregular, interlocking union of adjacent skull bones. These are called *sutures*. Notice variation in complexity of the suture pattern, and seek signs of closing of the joint which will be evidenced by obliteration of the suture line.

2. Contact surfaces may be bound together by fibrous cartilage which allows only a limited degree of movement. This type of joint is called a symphysis. Vertebrae are held together by this method as are the two pelvic bones anteriorly.

3. There are a number of types of freely movable joints:

(*a*) They may resemble a ball fitting inside a cup-shaped socket.

> *Look* at the head of the femur and the acetabulum into which it fits.

(*b*) They may be simply two flat surfaces sliding on each other.

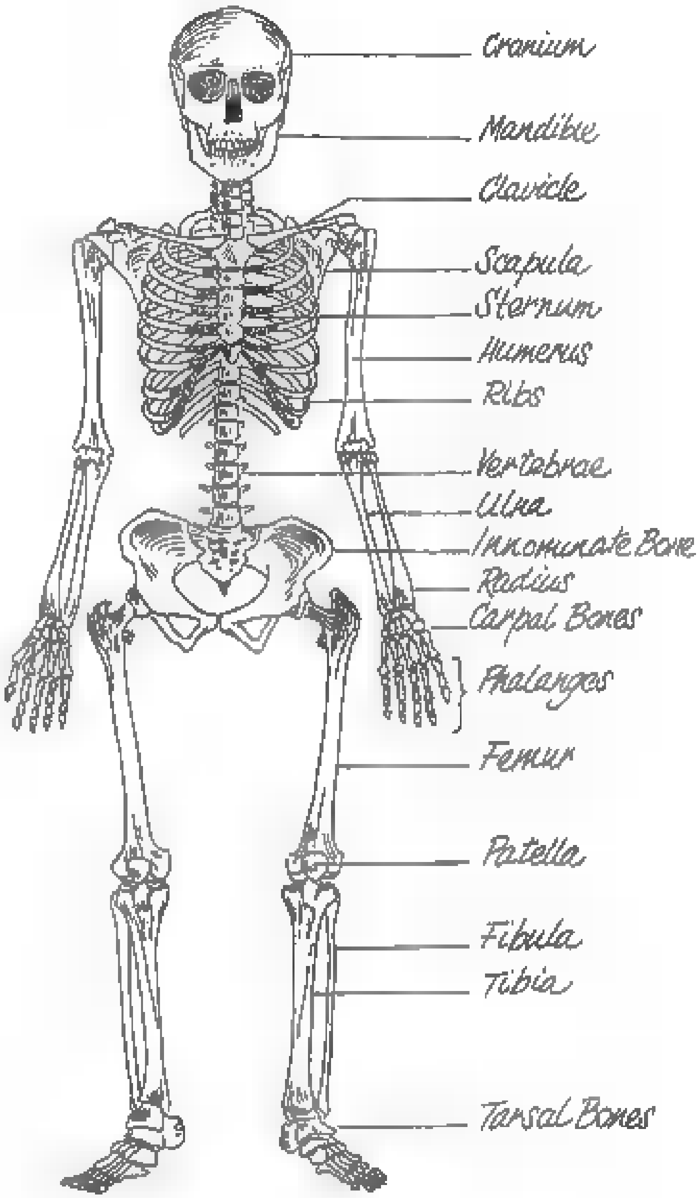
> *Look* at the joints between adjacent cubical bones of the wrist and ankle.

(*c*) Some joints move like a door on its hinges.

> *Look* at the joint between humerus and ulna.

(*d*) In others, the two bones pivot or rotate on each other.

> *Look* at the unusual joint at the proximal end of the radius where it rotates, end to end, on the capitulum of the humerus, and side to side in a notch on the lateral side of the ulna.



Cranium
Mandible
Clavicle
Scapula
Sternum
Humerus
Ribs
Vertabrae
Ulna
Innominate Bone
Radius
Carpal Bones
Phalanges
Femur
Patella
Fibula
Tibia
Tarsal Bones

Figure 1

CHAPTER II

THE SKELETON IN GENERAL

It is customary to divide the bones of the skeleton into two groups for descriptive purposes:

1. *The Axial Skeleton*, consisting of the skull and bones of the trunk.
2. *The Appendicular Skeleton*, comprising the bones of upper and lower limbs.

In this chapter, the skeleton will be reviewed in tabular form, listing for each bone its common name, anatomical term, and a brief description. This condensed information should be studied in conjunction with *Figure 1*, which illustrates the position of the various bones of the skeleton and their relation to each other.

In succeeding chapters, the parts of the skeleton will be described in greater detail according to regions. As each bone is studied, the text and illustration should be followed, together with careful examination of a specimen. It is always helpful to *feel* as well as *see* the described features. As each fact is learned, it should be a stimulus to further question: Why is this groove here? What sort of movements could occur at this joint?

Early in the learning process [redacted] should develop the habit of visualizing the appearance of [redacted] bone's mirror image so that we will be familiar with both right and left sides of the body.

THE SKELETON

Common Name	Anatomical Term	Brief Description
SKULL	1. *Bones forming the vault and enclosing the cranial cavity which accommodates the brain:*	
	Frontal (1) Parietal (2) Occipital (1)	From front to back, the curved flat bones of the roof or vault.
	Sphenoid (1) Ethmoid (1)	Delicate, complicated bones forming part of the floor of the cranial cavity.
	Temporal (2)	A pair of complex bones on the side of the skull helping to form the vault, and also containing the parts of the ear.
	containing: Malleus Incus Stapes	The tiny auditory ossicles or bones of hearing.
	2. *Bones forming the facial skeleton*	
	Nasal (2).........	Small bones of the bridge of the nose.
	Maxilla (2).......	The upper jaw.
	Lacrimal (2)......	Forms part of the eye socket or orbit.
	Vomer (1)........	Part of the septum dividing the nasal cavity into right and left sides.
	Palatine (2).......	Part of the roof of the mouth.
	Zygomatic........	The cheek bones.
	Turbinate bones (conchae).......	Three thin scrolls of bone extending into the nasal cavity.
LOWER JAW	Mandible.........	Horseshoe-shaped bone bearing the lower teeth and forming a joint with the skull.
	Hyoid............	A tiny bone in the neck region that helps to support the respiratory passages.
BACKBONE	Vertebrae.........	33 in number, divided into five regions:
	cervical (7)......	In the neck region.
	thoracic (12)....	In the region of the thorax.
	lumbar (5)......	In the lower back.

Common Name	Anatomical Term	Brief Description
BACKBONE (Cont.)	sacral (5).......	Fused together to form the posterior unit of the pelvic girdle — the sacrum.
	coccygeal (4).....	Fused together [redacted] form a tail piece — the coccyx.
BREASTBONE	Sternum, composed of:	
	manubrium.......	The uppermost segment, with which the clavicle and first rib articulate.
	sternebrae (4).....	Forming the body of the sternum and articulating with 2nd to 7th ribs.
	xiphoid process....	The tapered inferior part of the sternum.
CHEST	Thoracic Cage, formed by the 12 ribs..........	Which attach to the *vertebrae* behind and to the *sternum* in front.
PELVIC BONE	Innominate Bone, formed by fusion of ilium, ischium, and pubis	The right and left fuse with each other in front in the midline and unite [redacted] the sacrum behind, forming the basin-shaped bony pelvis.
Upper Limb		
COLLAR BONE	Clavicle..........	Acts [redacted] a strut to hold the shoulders back. Articulates medially with the *sternum* and laterally with the acromial part of the scapula.
SHOULDER BLADE	Scapula...........	The flat bone applied to the back of the thoracic cage. Articulates with the clavicle and has a hollow socket for the head of the humerus.
UPPER ARM	Humerus.........	A long bone extending from shoulder to elbow. Fits into a socket on the *scapula*, and articulates with *radius* and *ulna* distally.
FOREARM	Radius...........	The lateral (outer) bone of the forearm which articulates with the *humerus* end to end, and the *ulna* side by side.

Common Name	Anatomical Term	Brief Description
FOREARM (Cont.)	Ulna	The medial (inner) bone of the forearm which forms a hi[redacted] joint with the distal end of the *humerus* in the elbow region and articulates side by side with the radius.
WRIST	Carpal Bones hamate, capitate, lunate, triquetrum, trapezium, trapezoid, scaphoid, pisiform.	Composed of eight irregularly shaped bones arranged [redacted] a proximal and a distal row.
HAND	Metacarpals (5)	The long bones of the hand.
FINGERS	Phalanges (3)	On each finger.
	Phalanges (2)	On the thumb.
Lower Limb		
THIGH BONE	Femur	The large rugged bone of the thigh which articulates with the *tibia* at the knee and fits into a cup-shaped socket in the pelvic girdle.
KNEE CAP	Patella	A round flat bone within the tendon at the front of the knee.
SHIN BONES	Tibia	The larger bone of the lower leg which articulates at the knee with the *femur* proximally, and at the ankle, produces a fullness on the *medial* side.
	Fibula	The thin bone of the lower leg which lies lateral to the tibia and with it forms a mortice for the *talus*.
HEEL	Calcaneus	The large bone of the foot which forms the fullness we call the heel, supports the *talus* above, and articulates in front with the *cuboid*.
	Talus	The tarsal bone resting on the *calcaneus* and sandwiched between distal ends of *tibia* and *fibula*.

Common Name	Anatomical Term	Brief Description
Foot	Other Tarsal Bones:	
	Navicular......	A boat-shaped bone.
	Cuboid.........	A cubical bone.
	Cuneiforms (3)..	Wedge-shaped bones.
	Metatarsals (5)..	Long bones of the foot.
Toes	Digits.......... composed of phalanges	The first and fifth toes have two phalanges; the others have three phalanges.

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CHAPTER III

VERTEBRAE

VERTEBRAL COLUMN

The backbone or vertebral column is the central supporting structure of the body, the skull resting on its superior end, the pelvis attaching to its inferior part, and the ribs articulating with its intermediate portion. It usually consists of 33 individual bones called vertebrae.

Its interest to us may be summarized as follows:

1. It reflects functional change (e.g., the assumption of the erect posture by modern man).
2. The time of fusion of various vertebral elements is an indication of age (e.g., times of fusion of the segments of the sacrum).
3. Certain sex differences are shown in the vertebrae (e.g., the sacrum, being part of the pelvis, illustrates variations between male and female).
4. A number of pathological conditions attack the vertebrae and give some indication of the health and disease of the population being studied (e.g., bone tuberculosis invades the spine to produce what is called Pott's disease).

A TYPICAL VERTEBRA

Each individual vertebra is distinctive, and yet all share certain basic features. Study a typical vertebra and note its component parts, which are illustrated in *Figure 2*.

A. The *body* or centrum is the large, short, cylindrical anterior portion. Both upper and lower surfaces are in contact with a spongy intervertebral disc which acts [redacted] a shock absorber between adjacent vertebrae. The body remains a discrete entity for the early part of its development: only gradually do the posterior elements (which constitute the neural arch) fuse with it.

B. Projecting backwards are two short, thick processes which form the root-like attachment to the body of the neural arch. These are the *pedicles.*

C. The balance of the arch structure is completed by two plates or *laminae* which grow backwards and medially. These fuse together at their posterior edges in the midline and complete the outline of the large central hole in the vertebrae.

D. *The vertebral foramen,* through which passes the spinal cord. With the vertebral column in position, adjacent vertebral foramina form the tube-like *vertebral canal.*

E. The *spinous process* which arises at the junction of the fused laminae and projects downwards and backwards, serving as an attachment for muscles and ligaments of the back.

F. The *transverse processes* arising at the junction of the pedicles and laminae, and projecting laterally from the vertebral arch. In the thoracic region, transverse processes articulate with the neck of a rib.

G. Paired *superior articular processes* which contact the vertebra above.

H. Paired *inferior articular processes* which contact the vertebra below.

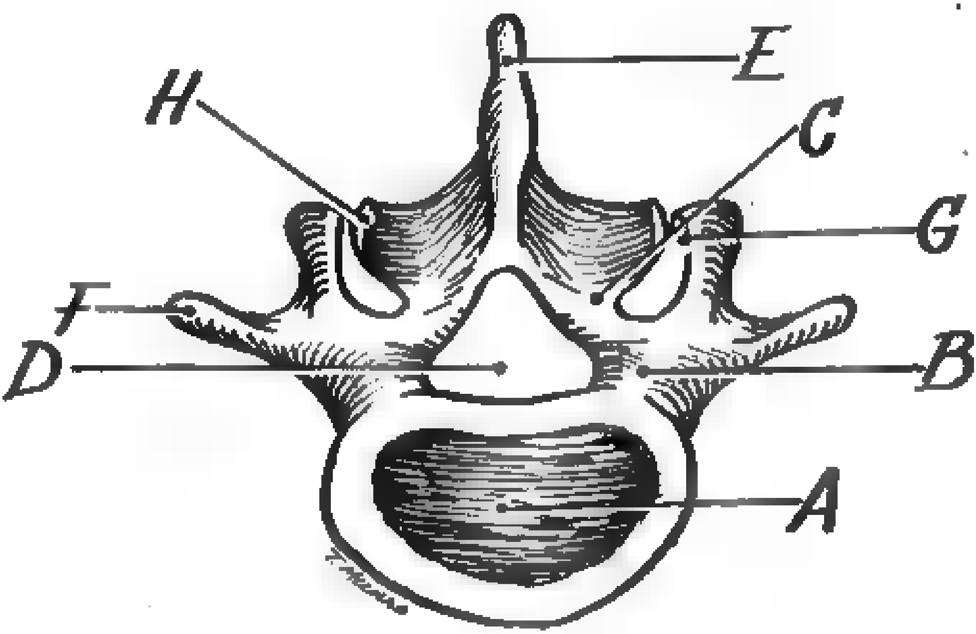


Figure 2

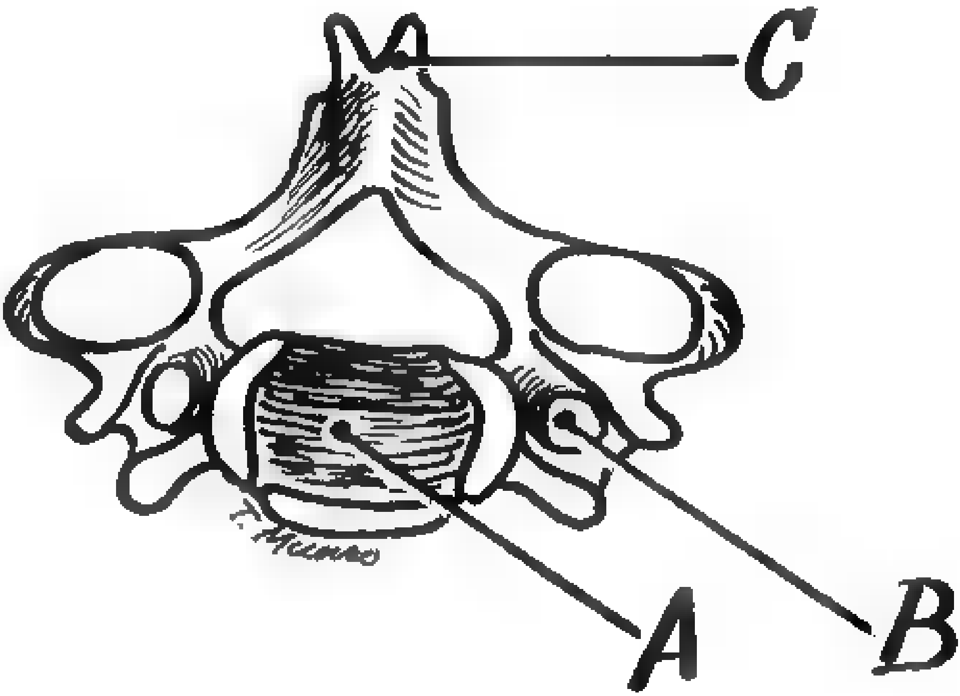


Figure 3

REGIONS OF THE VERTEBRAL COLUMN

We will now consider the vertebral column divided into five regions each with certain distinctive features. These [redacted] shown in the following chart:

Type	Region	Number	Distinctive Features
CERVICAL	NECK	7	Oval body, bifid spines, foramen transversarium
THORACIC	CHEST	12	Heart-shaped body, long spine, rib facets on body and transverse processes
LUMBAR	LOWER BACK	5	Kidney-shaped body, thick rugged vertebrae
SACRAL	PELVIS	5	Form a fused unit
COCCYGEAL	"TAIL"	3–5	Tiny, vestigial, fused elements

CERVICAL VERTEBRAE

Distinctive features of cervical vertebrae are shown in *Figure 3*:

A. An oval body with heaped-up superior edges.

B. A hole, the *foramen transversarium*, through which the vertebral artery ascends to the brain.

C. Bifid or double-tipped spinous processes (not present on first and last cervical vertebrae).

Two individual vertebrae are worth special consideration:

The atlas or first cervical vertebrae supports the skull much as the legendary hero, after whom it is named, supported the world. It consists of a bony ring with no vertebral body. This latter element has become fused with the second cervical vertebra to form the dens or odontoid process.

Note in Figure 4:

A. The area where the vertebral body should lie, now the resting place of the dens.

B. The huge cupped facets which bear the condyles of the skull.

C. Two small tubercles to which the transverse ligament attaches. This ligament separates the dens from the spinal cord and its coverings.

D. The small posterior tubercle which represents the spinous process on this vertebra.

The axis is the second cervical vertebrae. Fused to the upper surface of its body is the *dens* or *odontoid process* which protrudes upwards through the ring of the atlas.

THORACIC VERTEBRAE

Thoracic vertebrae have heart-shaped bodies and long spinous processes. Their distinctive characteristic is the presence of facets for articulation with ribs. Examine the diagram of two articulating thoracic vertebrae in *Figure 5*, and observe:

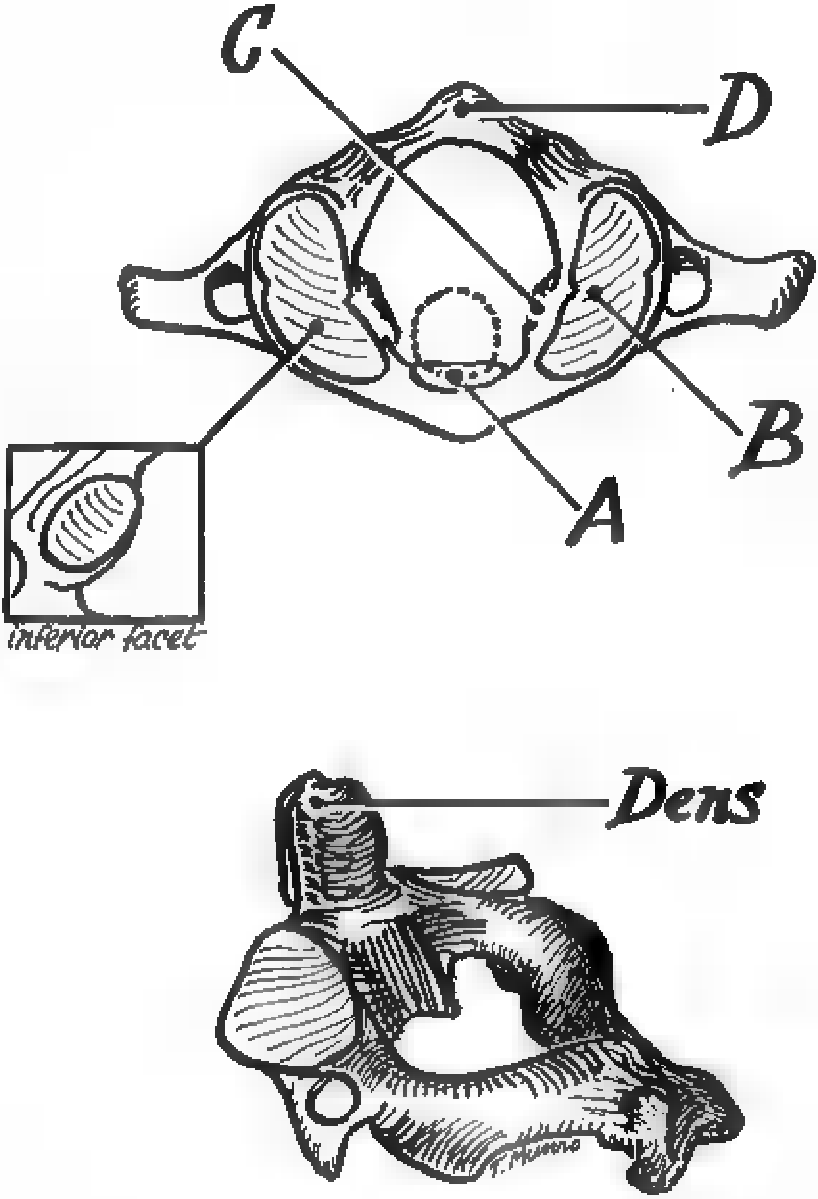
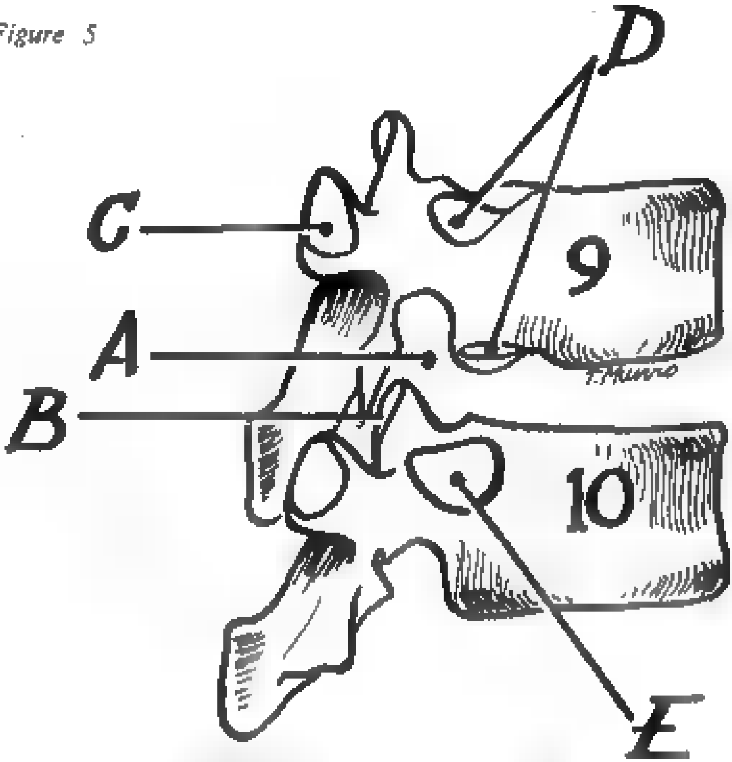


Figure 4

Figure 5



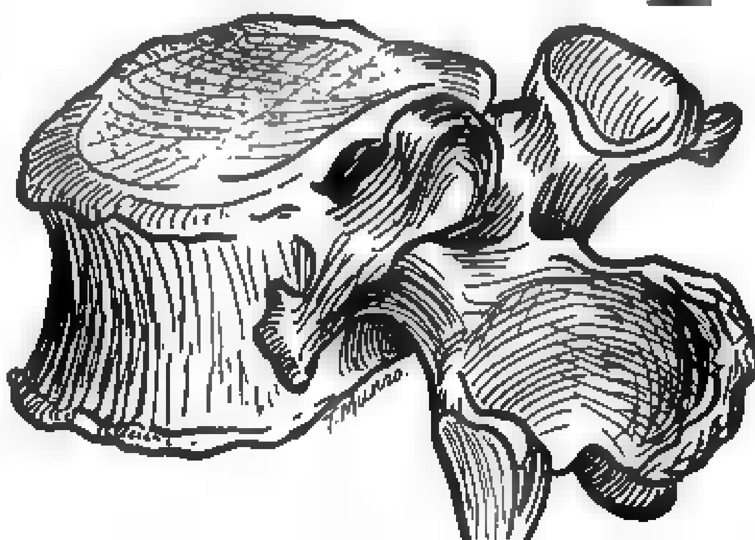


Figure 6

A. The foramen formed by notches on adjacent vertebrae. Through this opening passes, from the spinal cord, the nerve which supplies one segment of the body.

B. The manner in which superior and inferior articular facets of adjacent vertebrae articulate.

C. Facet on the transverse process for contact with a rib. This is present on the upper ten thoracic vertebrae.

D. An upper and lower facet for ribs found on the side of the body of thoracic vertebrae 2 to 9.

E. A single large facet for ribs found on the side of the body of thoracic vertebrae 1, 10, 11, and 12.

LUMBAR VERTEBRAE

The vertebrae of the lumbar region may be distinguished by exclusion: They have no foramen transversarium or facets for ribs. They are large, with kidney-shaped bodies, slender transverse processes (they have no ribs to bear), and deep hatchet-shaped spinous processes. These features may be seen in *Figure 6*.

SACRUM

In the adult, the five sacral vertebrae are fused together providing a thick triangular bone which forms part of the wall of the pelvic basin. Study *Figure 7*.

Note:

A. The fused sacral *bodies*, centrally.

B. The fused transverse elements forming the *lateral mass*. Its upper end is called the *ala* (or wing) of the sacrum.

C. Between body and lateral mass, a line of four *anterior sacral foramina* through which the nerves from the sacral segment of the spinal cord pass.

D. The anterior projection of the first body, described as the *promontory* of the sacrum.

E. Laterally, articulation with the ilium.

F. Superiorly, articulation with the fifth lumbar vertebra.

G. Inferiorly, articulation with the coccyx.

COCCYX

The wedge-shaped termination of the vertebral column, consisting of three to five segments.

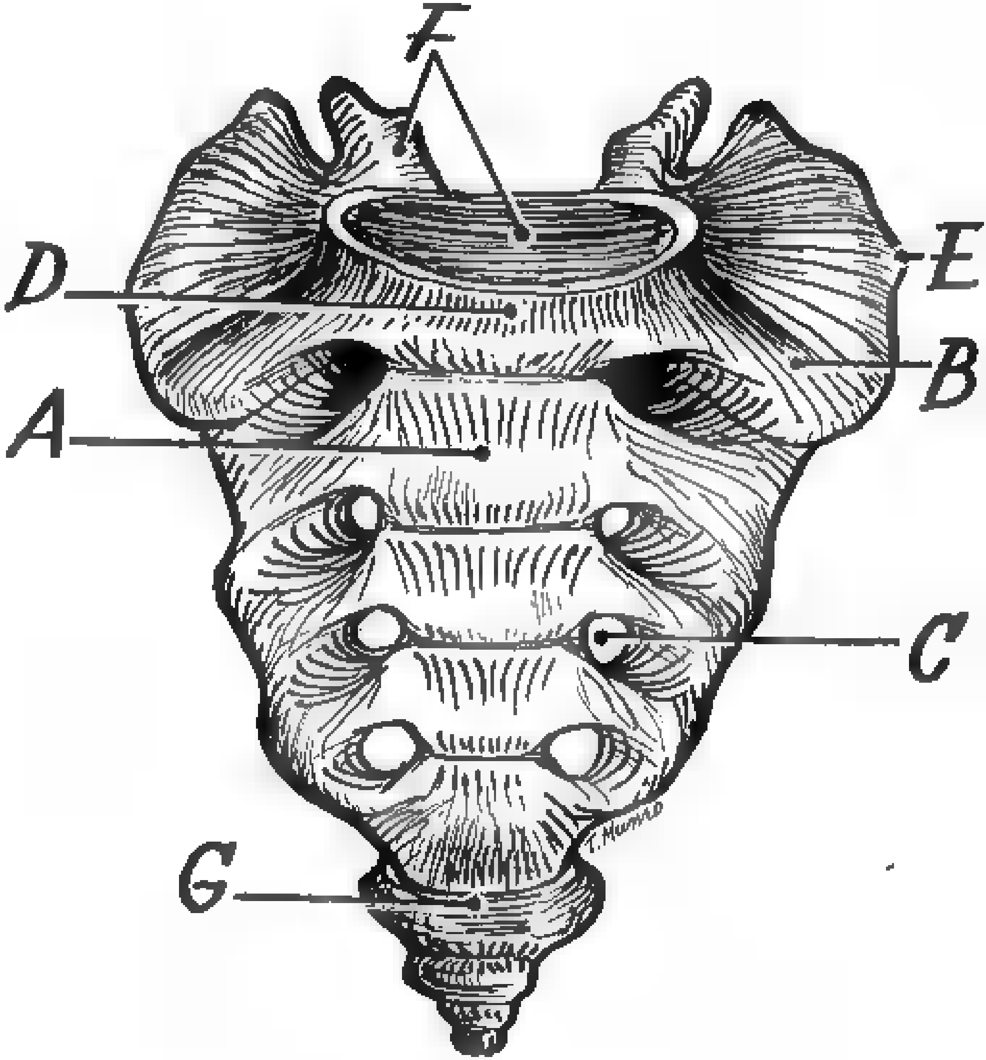


Figure 7

Figure 8

CHAPTER IV

UPPER LIMB

CLAVICLE

(*Clavicula = a small key*)

The clavicle or collar bone acts as a strut to hold back the shoulder girdle. It articulates medially with the upper part of the sternum which is called the manubrium. Laterally, its articulation is with [redacted] facet on the acromion, a process of the scapula.

To determine left from right, the following facts are useful:

1. The medial end is thick and round; the lateral is thin and flat.
2. The clavicle is convex medially and concave laterally. This you [redacted] verify by feeling your own clavicle.
3. The upper surface is smooth, the lower rough for muscle and ligament attachment.

Notice in Figure 8:

A. Facet for acromion.

B. Trapezoid line, and C. Conoid tubercle, both for ligament attachment.

D. Rough area for costoclavicular ligament.

E. Articular [redacted] for sternum.

SCAPULA

Perhaps the simplest way to study the scapula or shoulder blade is to consider it as a flat triangular bone with added detail. Two views of the scapula are shown in *Figure 9*. When we examine the *anterior view*, we are looking at the surface which is in contact with the thorax.

Note that—

A. The angle between the superior and the lateral borders is flattened to form an oval socket (the *glenoid fossa*) which articulates with the head of the humerus to form the shoulder joint.

B. Just medial to this, the superior border appears pulled out into a finger-shaped structure called the *coracoid process.*

C. Still further medial on the superior border is the *suprascapular notch* for transmission of a nerve and artery.

D. The *lateral border* is strengthened by a strong bar of bone to withstand the resultant forces exerted by muscles attached to the scapula.

E. A facet for articulation with the clavicle.

In posterior view note:

F. The *spinous process* arising from the back of the scapula.

G. The *acromion* which is the lateral rectanguloid termination of the spinous process.

H. The interval between the lateral edge of the spinous process and body of scapula. This is known as the *spino-glenoid* notch.

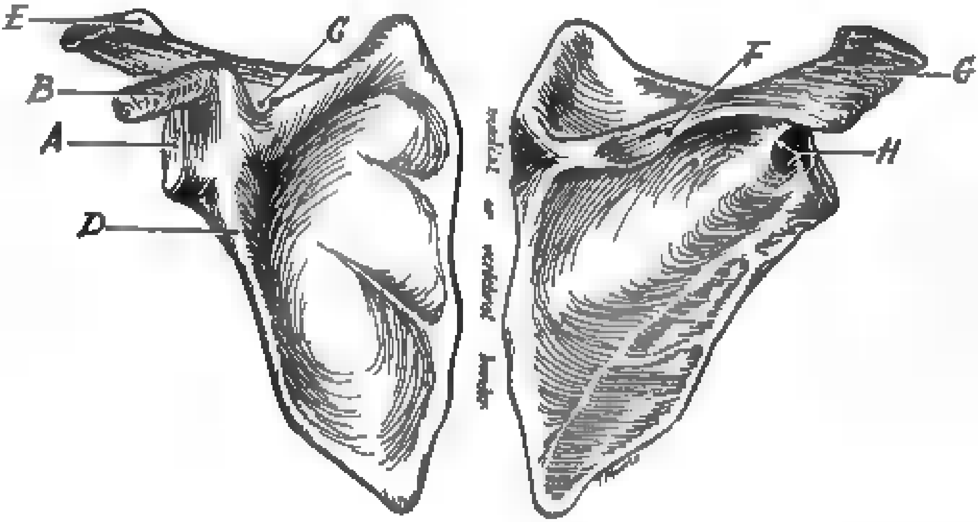


Figure 3

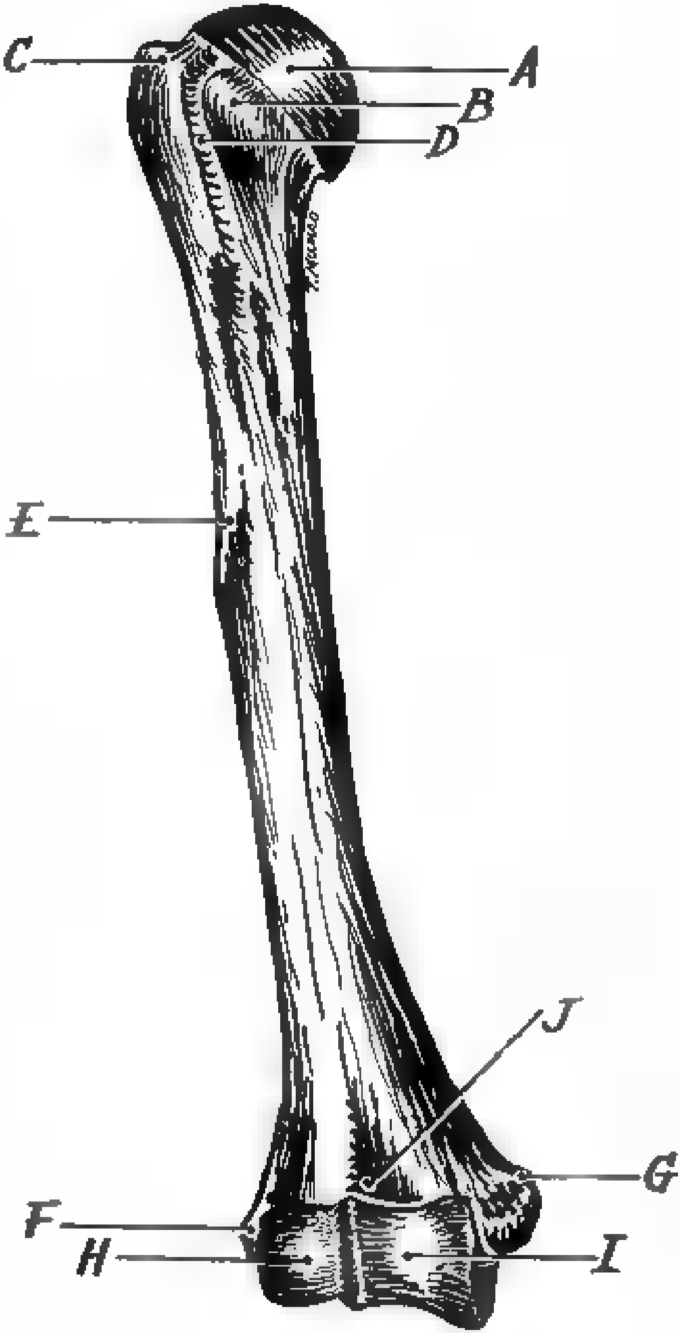


Figure 10

HUMERUS

The long bone of the upper arm, the humerus, is illustrated in *Figure 10*. The humerus articulates proximally with the scapula by means of a ball-and-socket joint; distally it articulates at the elbow with radius and ulna.

Note the following distinctive features:

A. The smooth round *head* at the proximal end.

B. The *lesser tuberosity*: a lump for muscle attachment, which faces straight forward in the anatomical position.

C. The *greater tuberosity*: a much larger lump lateral to the head.

D. A groove between greater and lesser tuberosities, for passage of the tendon of the biceps muscle: the *bicipital groove*.

E. A V-shaped rough area on the lateral side of the shaft for the attachment of the deltoid muscle which gives it the name of *deltoid tuberosity*.

F. The small rough area on the lateral side of the distal end: the *lateral epicondyle*.

G. The larger *medial epicondyle*.

H. The lateral rounded knob—the *capitulum*—which articulates with the proximal end (or head) of the radius.

I. The medial spool-like structure—the *trochlea*—which articulates with the proximal end of the ulna.

J. The little depression into which the coronoid process of the ulna dips when the elbow is flexed. It is called the *coronoid fossa*.

The distal end of the humerus, as seen in posterior view, is remarkable because of the deep pit (*olecranon fossa*) into which the olecranon process of the ulna moves when the arm is straightened out or extended.

RADIUS AND ULNA

Radius and ulna are the two bones of the forearm extending from elbow to wrist. The radius is lateral in the anatomical position. Consult *Figure 11*.

Note the following:

A. The *head of the radius* which articulates proximally with the capitulum of the humerus. The constriction just distal to the head is called the *neck*.

B. The *radial notch* of the ulna into which the head of the radius fits.

C. The *olecranon process*, a hook-shaped extension of the ulna's proximal end which articulates with the trochlea on the humerus. When the arm is straightened (extended), the olecranon process fits into its fossa on the humerus.

D. The *coronoid process* is a sharp lip that projects into the coronoid fossa of the humerus when the elbow is bent (flexed).

E. The *radial tuberosity* to which the strong biceps muscle is attached.

F. The opposed sharp *interosseous borders* of radius and ulna. At midshaft both bones [redacted] triangular in cross-section.

G. The *head of the ulna* which is distal and related to a *styloid process*.

H. The expanded distal end of the radius which articulates with carpal bones to form the wrist joint and bears [redacted] *styloid process*.

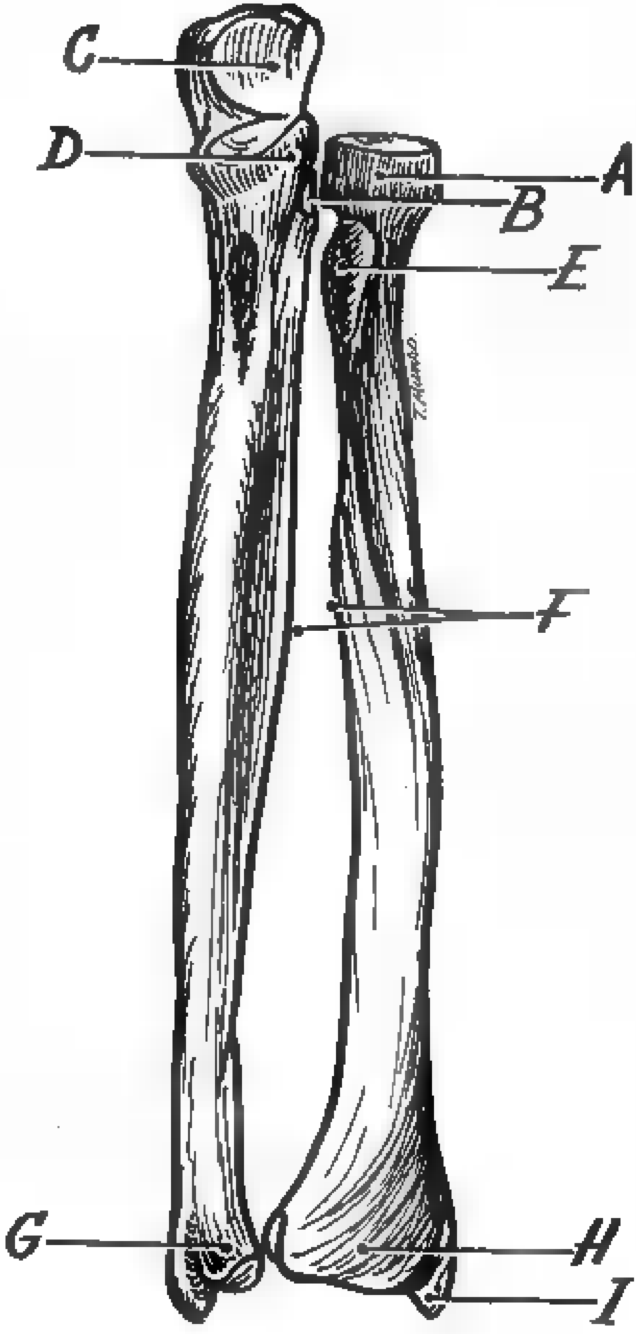


Figure 11

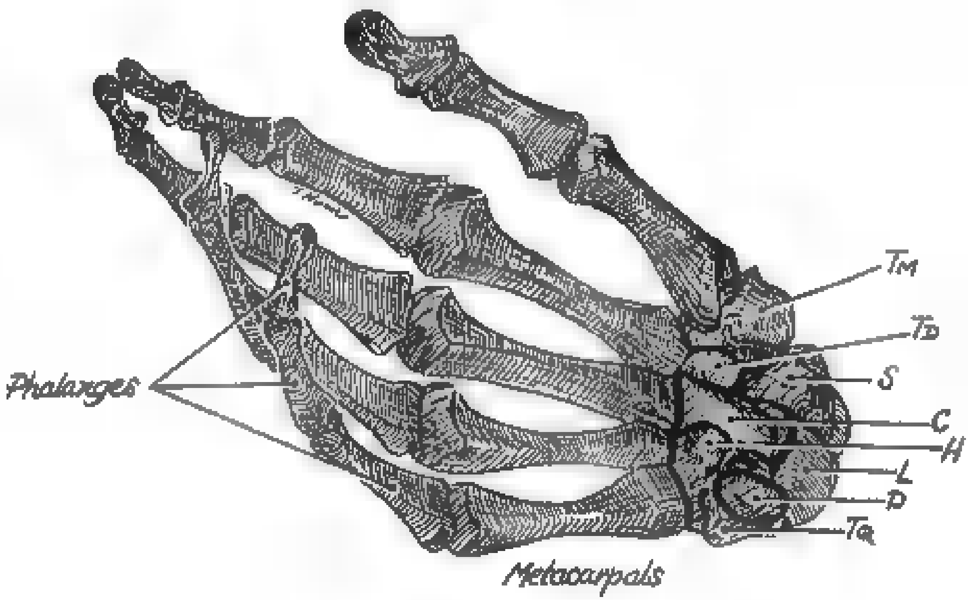


Figure 12

HAND AND WRIST

The skeleton of the hand and wrist is illustrated in *Figure 12*. Eight tiny carpal bones form the wrist. They are arranged in two rows, proximal and distal.

The proximal row consists of scaphoid, lunate, triquetrum, and pisiform. The latter is placed anterior to the triquetrum. These bones articulate with the distal end of the radius to form the wrist joint.

The distal row includes hamate, capitate, trapezoid, and trapezium. This group articulates with the proximal row of carpal bones and also with proximal ends of the metacarpals.

The metacarpals are the long bones of the hand. They have rounded knuckle-like heads distally, and flat articular areas proximally for contact with the distal row of carpal bones.

The phalanges form the skeleton of the fingers. The first digit or thumb consists of two phalanges, a proximal and a distal. The other digits have proximal, middle, and distal phalanges. The anterior or palmar surface of each is flattened. The distal end of each is called the head, and in the distal phalanx this area is flattened and shaped like an arrowhead.

CARPALS

As shown in *Figure 13,* certain distinctive features of each carpal bone make it readily identifiable:

Pisiform (pisum=a pea) the smallest and simplest, resembling a pea with one flat area: the articular facet for the triquetrum.

Hamate (= hooked) has a *large hook* protruding from its body.

Capitate (caput=head) has a fancied resemblance to a judge's *head* with legal wig.

Scaphoid (=like a boat) resembles a viking ship with a prow, which is the tubercle; a keel, which articulates with the radius; and a concave deck into which the head of the capitate fits.

Lunate (Luna=moon) a small bone resembling a half moon.

Trapezium (a geometrical figure having two parallel sides and two diverging sides) has a marked ridge and an accompanying groove on its anterior surface.

Triquetrum (Triquetrus=three-cornered) is shaped like a pyramid and has the flat oval facet for the pisiform on its anterior surface.

Trapezoid (like a trapezium) resembles a high cut boot whose sole is the larger of two non-articular surfaces.

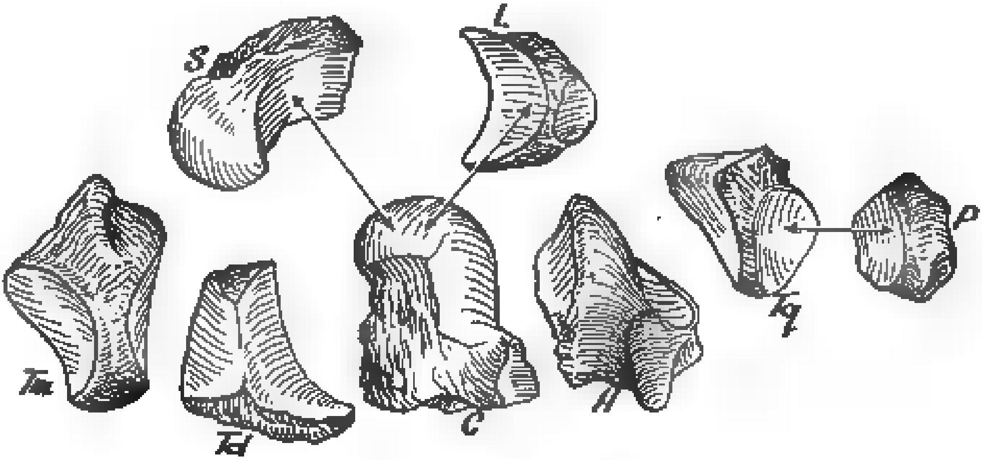


Figure 13

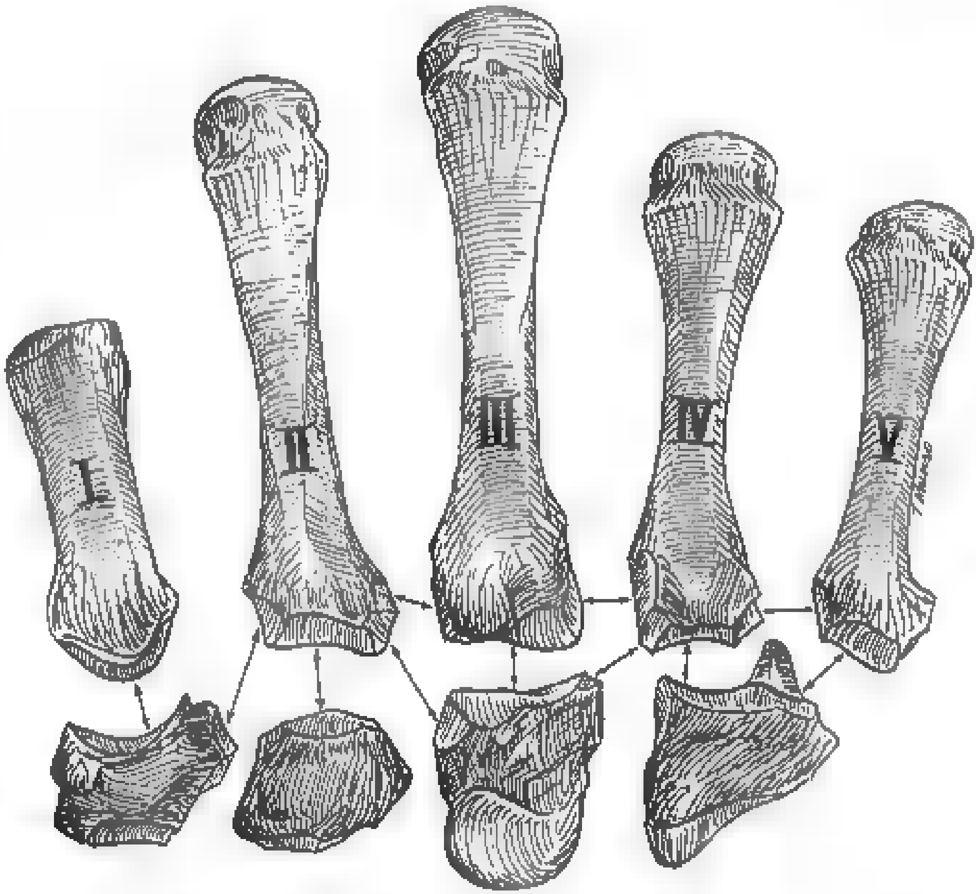


Figure 14

METACARPALS

If we examine the metacarpals in closer detail, we will note that they may be readily distinguished from each other by the articular facets on their proximal ends. *Figure 14* and the accompanying chart illustrate this.

Metacarpal	Number of articular facets	Bones with which it articulates
I	One	Trapezium—reciprocally saddle-shaped
II	Four	Metacarpal [illegible] Capitate Trapezoid Trapezium
III	Three	Metacarpal 4 Capitate Metacarpal 2 (also bears a styloid process)
IV	Four	Metacarpal 5 Hamate Capitate Metacarpal 3
V	Two	Hamate Metacarpal 4

Metacarpals II and IV each have four articular facets proximally, but may be distinguished by the fact that IV has two round facets side by side on the lateral surface for capitate and metacarpal III.

Chapter V describes the phalanges of fingers and toes.

CHAPTER V
LOWER LIMB AND PELVIS
PELVIS

The pelvis is a bony basin composed of three elements, the sacrum and the right and left innominate or hip bones. These latter two bones articulate with each other in the midline anteriorly. Posteriorly, they sandwich the sacrum between them in a side-to-side relationship. The sacrum is described with the vertebral column. We shall now examine the innominate bone.

The innominate or hip bone is formed from three separate bones which fuse together at puberty. They are named *ilium*, *ischium*, and *pubis*. *Figure 15* shows the pelvis with sacrum removed.

Note:

A. The *iliac crest*. Below it, the concave iliac fossa.

B. *Anterior superior* spine, the termination of the iliac crest in front.

C. *Posterior superior spine*, the termination of the crest behind.

D. *Anterior inferior spine*.

E. *Posterior inferior spine*.

F. The *iliac tuberosity*, a roughened area for the attachment of strong ligaments binding the ilium to the sacrum.

G. The *auricular surface*, [redacted] ear-shaped area for articulation with the sacrum.

H. The *ischial spine*.

I. The *ischial tuberosity*.

J. The *obturator foramen*.

K. The *symphysis pubis*, the area in the median plane where right and left pubic bones articulate with each other, fibrocartilage intervening.

L. The *pubic tubercle*.

M. The *acetabulum*, which forms the socket for the head of the femur. The articular surface is horseshoe-shaped. Between the open limbs of the horseshoe is the acetabular notch.

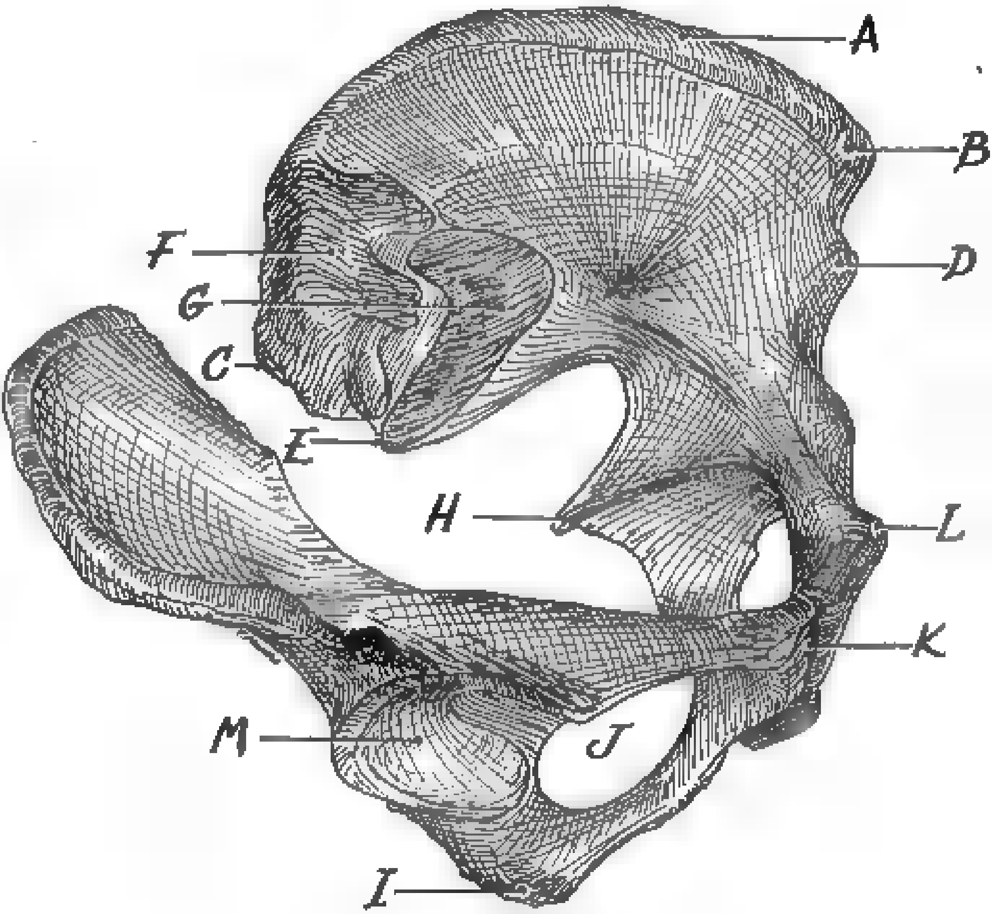


Figure 15

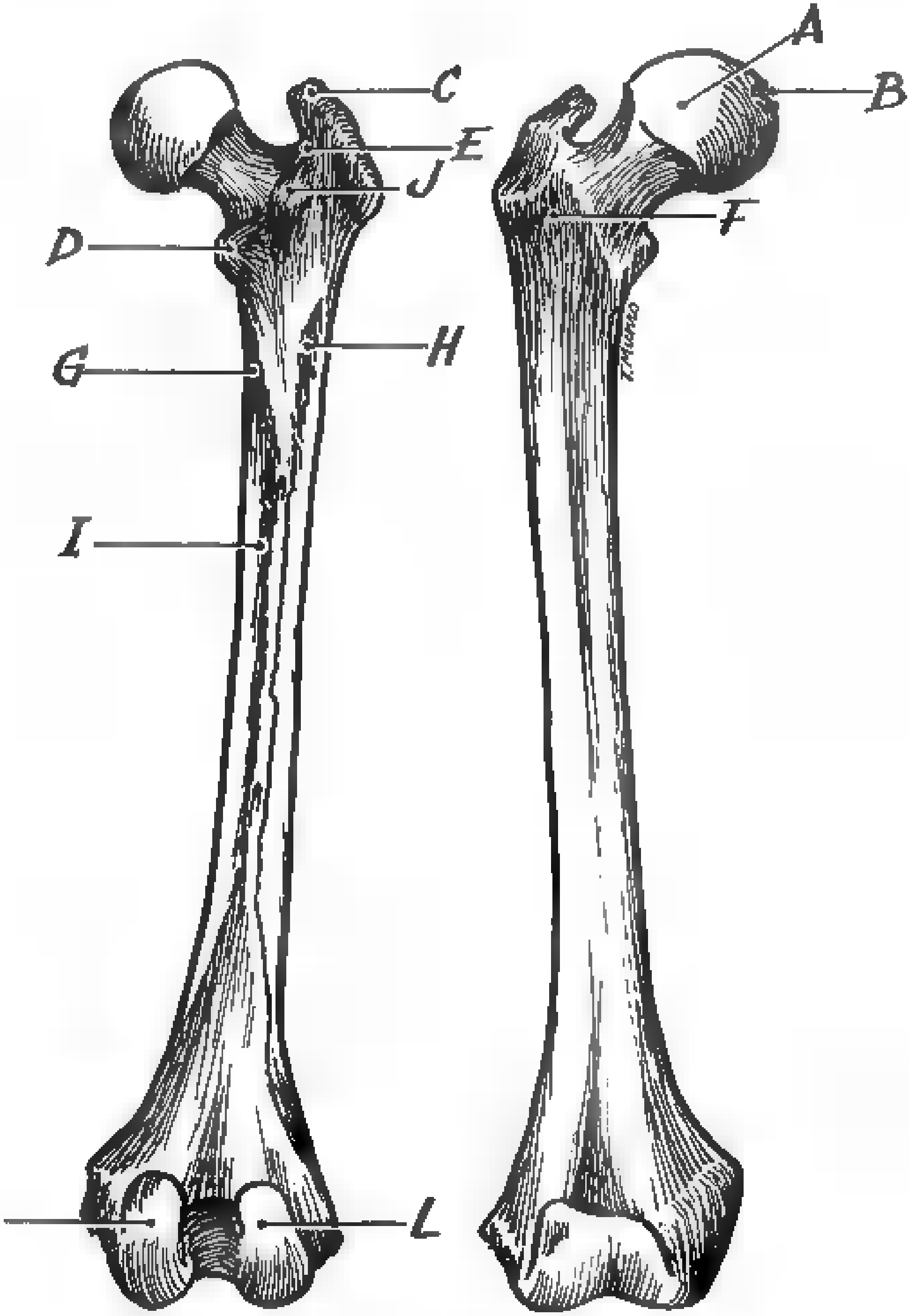


Figure 16

LOWER [redacted]

[redacted]

This, the longest and most rugged bone of the skeleton, is from 15 to 18 inches long in the adult. As we learn its landmarks, we may also review some of our general knowledge of bones.

Notice carefully in Figure 16 and on the femur:

A. The round *head* which forms two-thirds of a sphere. How does it differ from the head of the humerus? Where is its socket ? Why is it smooth ?

B. The *pit* on the head. What is its function?

C. The *greater trochanter*. How is it formed ?

D. The *lesser trochanter*.

E. *Intertrochanteric crest.*

F. *Intertrochanteric line.*

G. *Spiral line.*

H. *Gluteal tuberosity.*

I. The *linea aspera*. By what is it formed ?

J. The *quadrate tubercle*.

K. *Medial condyle* (and its epicondyle above).

L. *Lateral condyle and epicondyle* ("epi" = means above). With what do the condyles articulate ? Trace out the edge of the articular surface all the way around the distal end of the femur.

Look along the linea aspera and find [redacted] or [redacted] holes that transmit vessels to supply the bone. These openings are called *nutrient foramina.* In what direction do they point? They [redacted] commonly directed away from the most rapidly growing end of a long bone. You might be interested in checking other long bones for the direction of their foramina and might come to some conclusion as to where the [redacted] of greatest growth in the skeleton occur.

Examine the shaft of the femur, and notice that there is a variable degree of bowing and also [redacted] torsion of the distal end relative [redacted] the proximal. Variation of these two factors may be linked to function.

PATELLA

The patella is [redacted] sesamoid bone located in a tendon in front of the distal end of the femur. It is almost triangular in shape, with its base proximal and its apex distal. Its posterior surface is smooth and articulates with the femur; it is divided into a larger lateral area and [redacted] smaller medial one. Because of this, when a patella is placed on the table with posterior surface downward and apex directed away from the observer, the bone falls to its own side. The anterior surface is rough, ridged, and pitted.

These features may be seen in *Figure 17*.

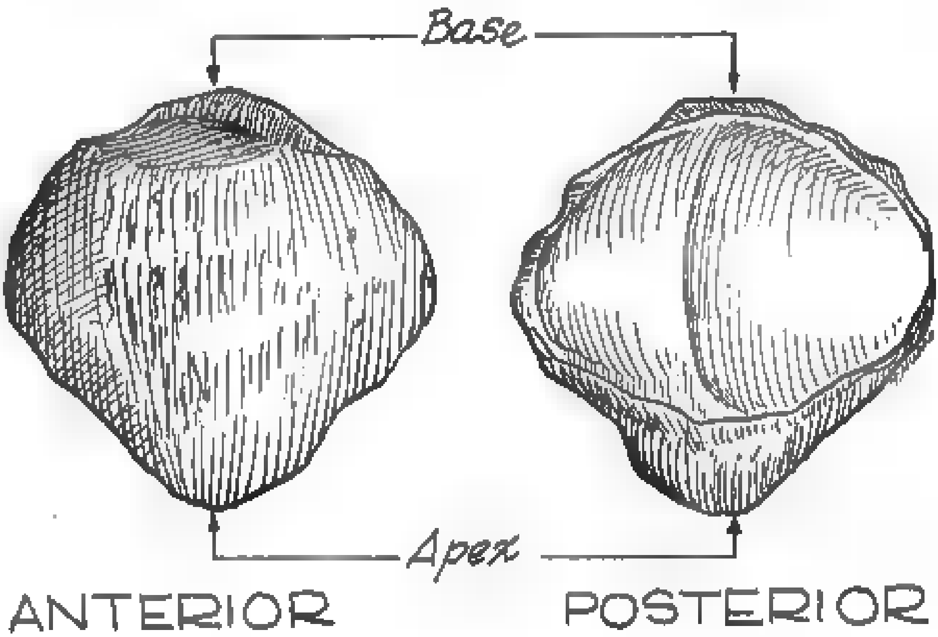


Figure 17

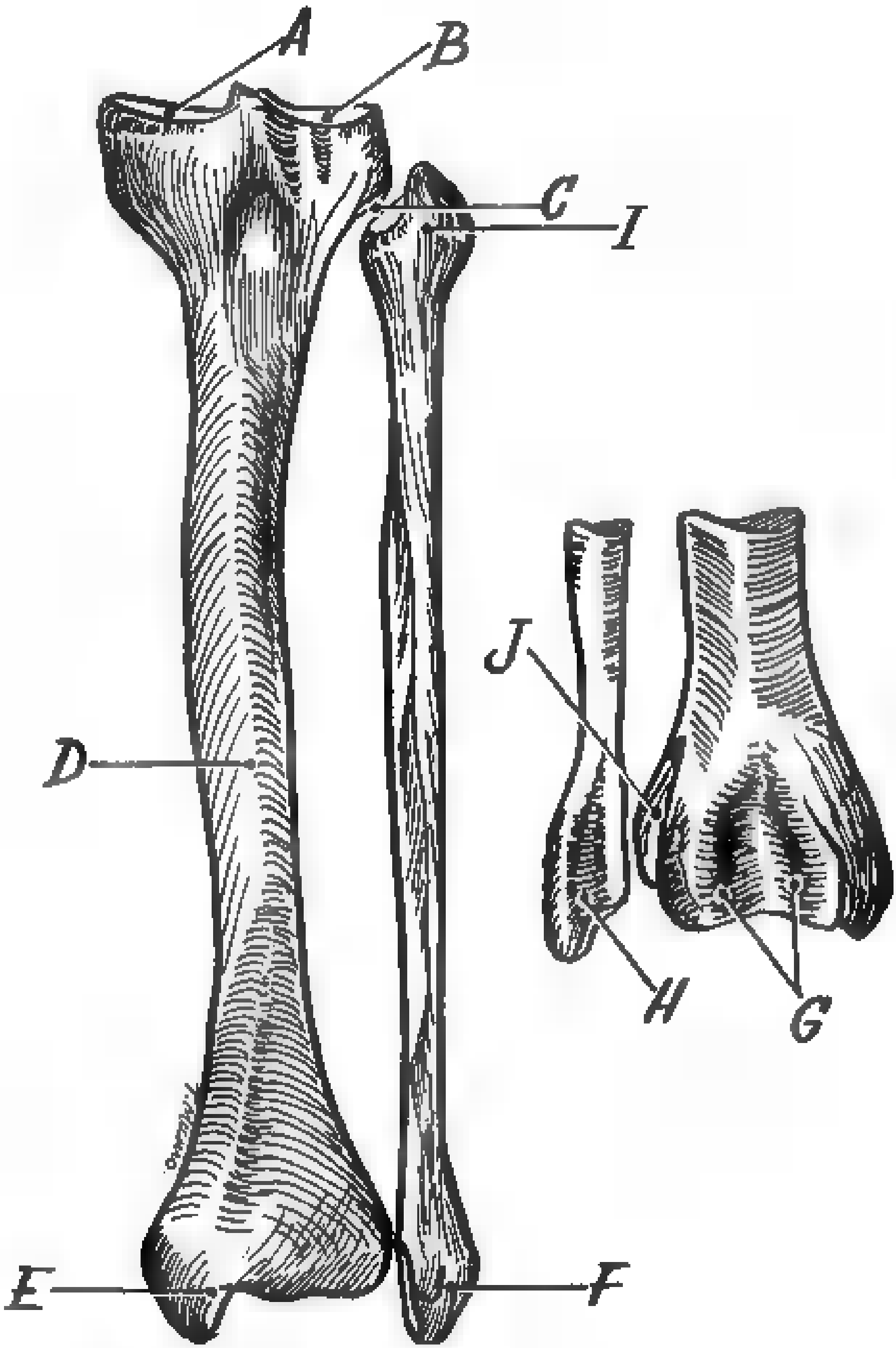


Figure 18

TIBIA AND FIBULA

These two bones, which are illustrated in *Figure 18*, form the skeleton of the lower leg between knee and ankle. The tibia is larger and medial.

On it *note*:

A. *Medial condyle*.

B. *Lateral condyle*.

C. A facet on the posterior part of an overhanging ledge on the lateral side of the tibia for articulation with the proximal end of the fibula.

D. The flat surface of the tibia lying just under the skin, which we can feel on ourselves and call the "shinbone."

E. The *medial malleolus* which, together with F, the *lateral malleolus* of the fibula, grasps the talus (one of the tarsal bones) like a mortice. This is the true ankle joint where movements of flexion and extension occur.

G. The two grooves on the back of the tibia's distal end, which are formed by tendons hooking around.

H. A groove similar to G, on the back of the distal end of the fibula. This is a valuable guide to the posterior surface of the fibula when orienting it to determine left and right.

I. The *head* of the fibula, which is round [redacted] opposed to the flattened distal end. On it [redacted] be noted a flat facet for articulation with the tibia.

J. Points to the articular notch on the tibia which bears the fibula in a side-by-side articulation.

TARSUS

Figure 19 illustrates the skeleton of the articulated foot.

The posterior half of the foot is assembled from seven tarsal bones somewhat similar to the bones of the wrist.

The Talus (or ankle bone), as we have already mentioned, is the bone sandwiched by the medial and lateral condyles of tibia and fibula. It has articular areas for these bones as well as for the calcaneus upon which it rests. Its head, which is directed forward, articulates with the navicular, much as the head of the capitate articulates with the lunate in the wrist. Examine the bones of the foot and see how the talus contacts each of the bones mentioned.

The Calcaneus (or heel bone) supports the talus above and articulates with the cuboid anteriorly.

Note in Figure 20:

A. Its projecting, rough posterior part to which the tendon of Achilles attaches.

B. The medial shelf known as the *sustentaculum tali*. Under it there is a groove (C) for the tendon of the long flexor of the great toe.

D. The anterior, middle, and posterior facets for bearing the talus. There is considerable variation in their appearance. Anterior and middle facets may be discrete, single, or partially blended together.

E. The anterior articular surfaces for the cuboid.

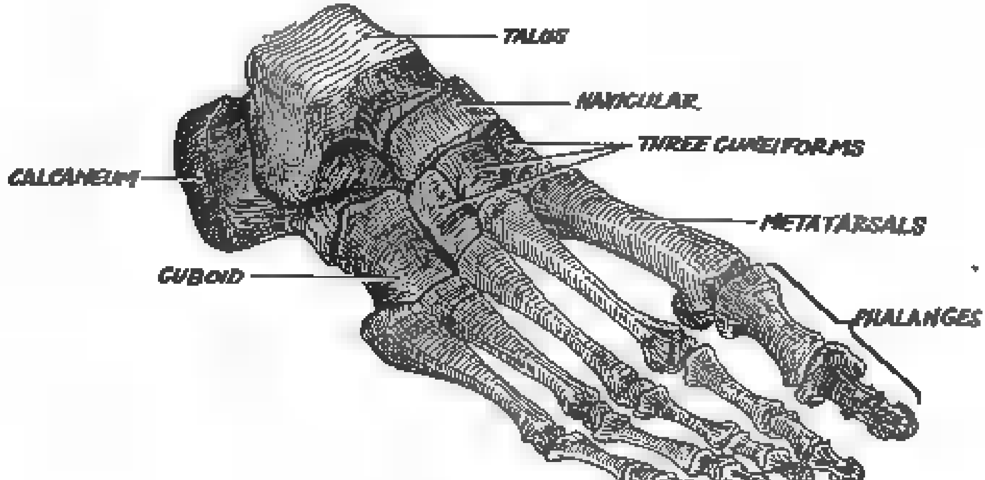


Figure 19

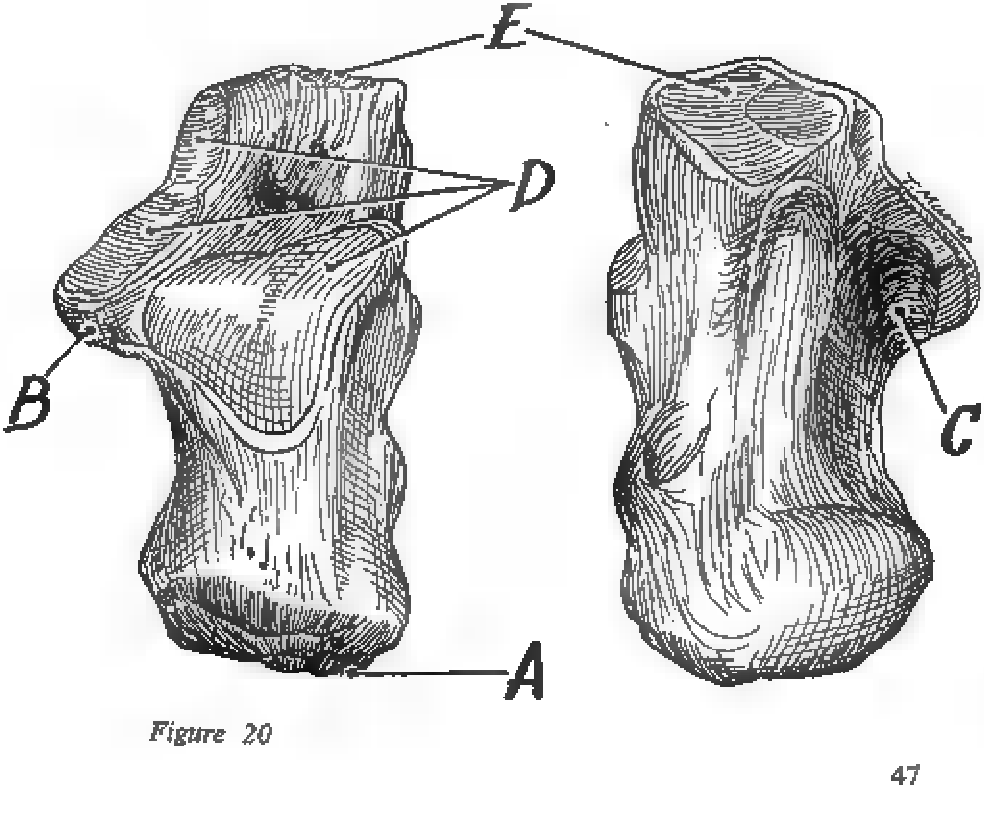


Figure 20

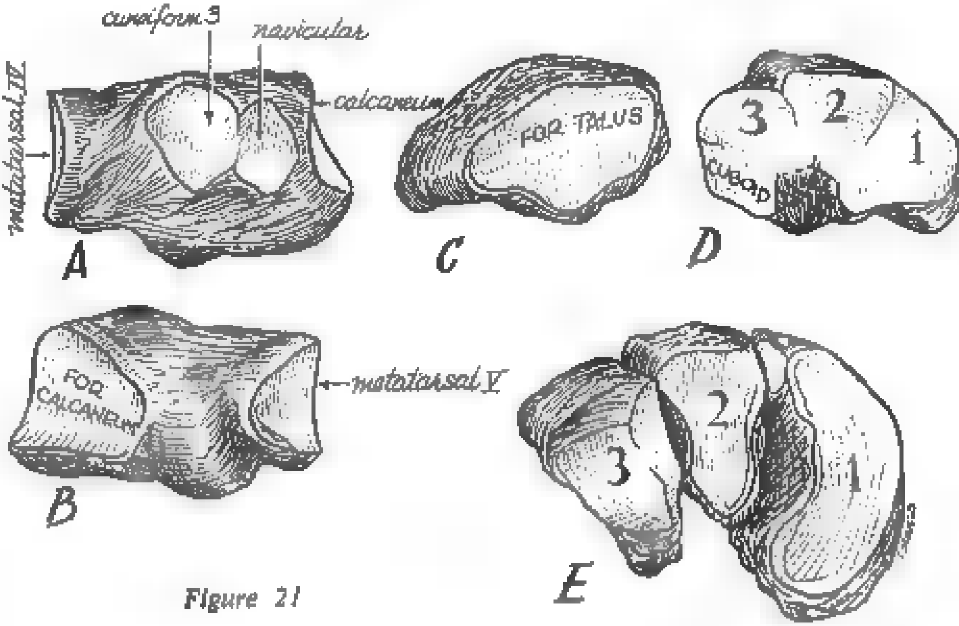
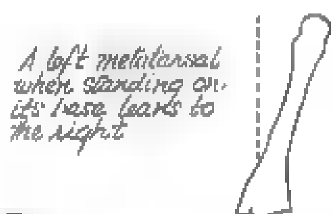


Figure 21

METATARSALS



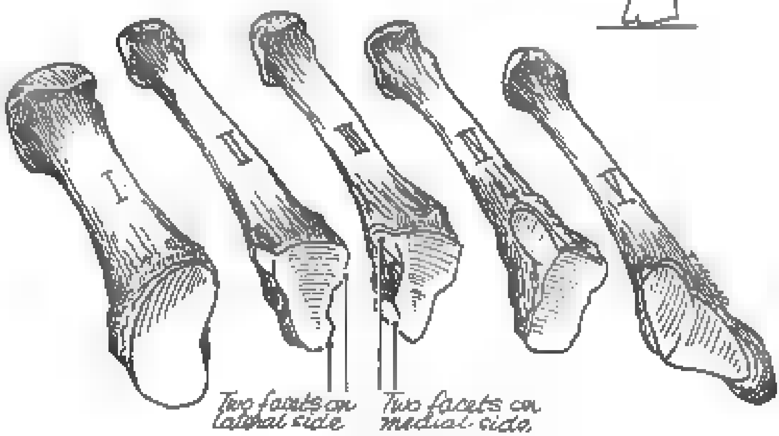


Figure 22

The Other Tarsal Bones

Examine again *Figure 19,* noting the relationships of the other tarsal bones: *navicular, cuboid,* and three *cuneiforms.*

Figure 21 shows [redacted] detailed views of these bones from a right foot:

A. A medial view of the cuboid showing articular facets for the 4th metatarsal, 3rd cuneiform, navicular, and calcaneus.

B. A lateral view of the cuboid, with articular areas for the calcaneus and the 5th metatarsal.

C. The proximal surface of the navicular, with the socket for the head of the talus.

D. The distal surface of the navicular is partially subdivided into three areas for articulation with the three cuneiforms. There is a facet on the lateral side for articulation with the cuboid.

E. The distal surfaces of the three cuneiforms showing the distinctive facets for articulation with the first three metatarsals.

METATARSALS

There are five long bones—the metatarsals—which comprise the greatest part of the skeleton of the foot. The larger proximal end of each is called the base, and the rounded distal end is the head. These bones are shown in *Figure 22*.

The 1st metatarsal is thick and rugged. Its kidney-shaped base articulates with the medial cuneiform. The undersurface of the head has two grooves for tiny sesamoid bones.

The 2nd, 3rd, and 4th metatarsals may be distinguished by examining the facets on their bases.

The 5th metatarsal is notable because of the large tubercle on the lateral side of its base.

TOES

The first digit or great toe consists of two phalanges; the other digits have three: proximal, middle, and distal. The distal and middle phalanges of the 5th digit have fused together.

HAND AND FOOT

Figure 23 consists of a series of three diagrams showing comparisons between the long bones of the hand and those of the foot.

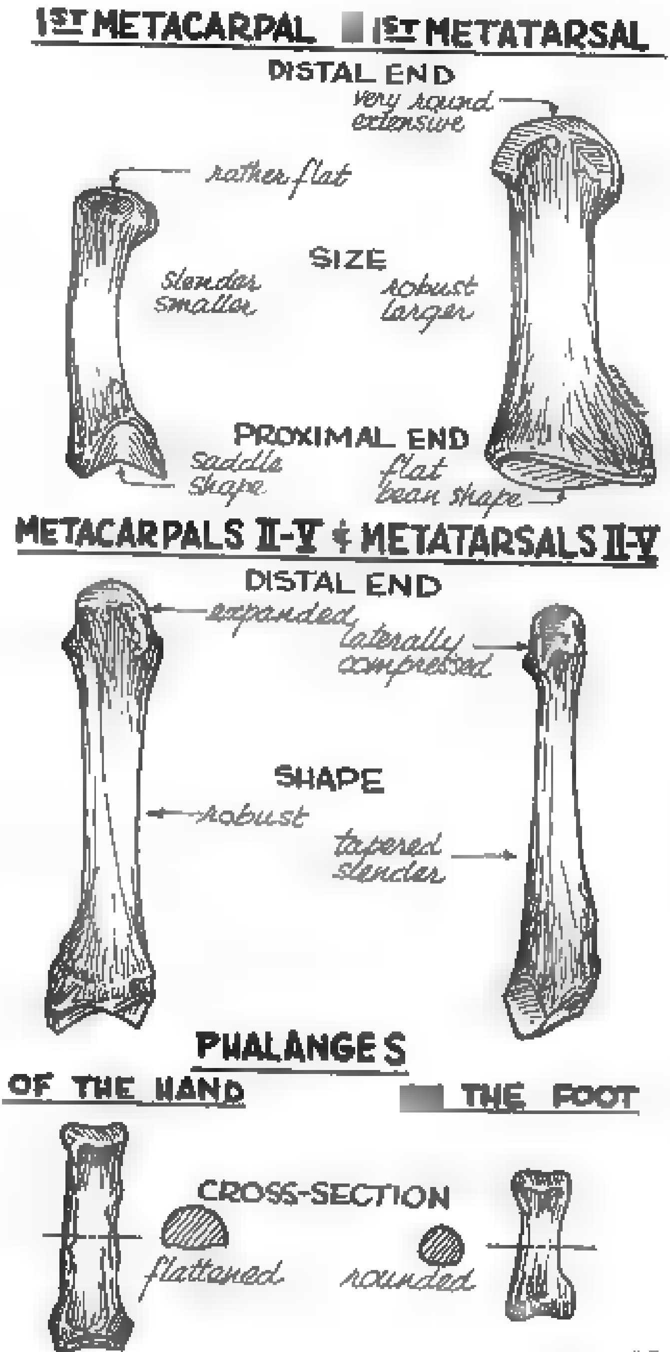

1ST METACARPAL
1ST METATARSAL
DISTAL END
very round extensive
rather flat
SIZE
slender smaller
robust larger
PROXIMAL END
saddle shape
flat bean shape
METACARPALS II-V & METATARSALS II-V
DISTAL END
expanded
laterally compressed
SHAPE
robust
tapered slender
PHALANGES
OF THE HAND
THE FOOT
CROSS-SECTION
flattened
rounded

Figure 23.

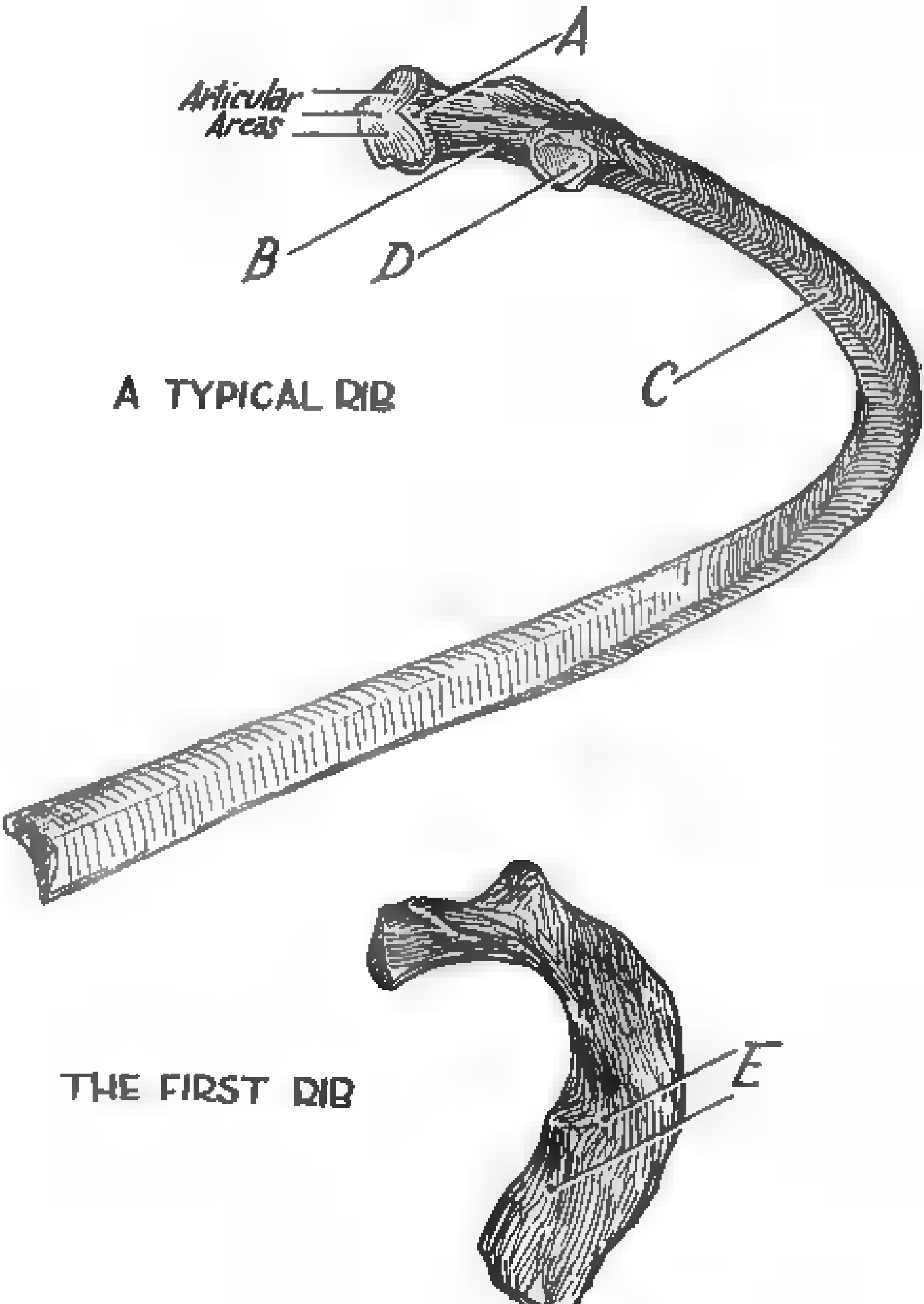


Figure 24

CHAPTER VI

THE THORACIC CAGE

The thoracic cage is [redacted] basket-like container for such vital organs as heart, lungs, and the great vessels. Consult *Figure 1* and the skeleton, and notice that the component bones [redacted] the twelve thoracic vertebrae, the twelve ribs, and the sternum or breast bone.

Examine the drawing of a typical rib shown in *Figure 24*:

A. The *head* of the rib which articulates with facets on two adjacent thoracic vertebral bodies and their intervertebral disc.

B. The *neck* of the rib.

C. The *shaft*, whose inferior edge is flanged, forming the costal groove which lodges intercostal vessels and nerves.

D. The *tubercle*, at the junction of the neck and the shaft. It bears a facet which articulates with the transverse process of a thoracic vertebra.

Also shown in *Figure 24* is the upper surface of a left *first* rib. The first rib is notable in being shorter, wider, and flatter than the others. The pointers (E) draw attention to grooves, formed by the artery and vein, which pass over it.

Anteriorly, ribs are replaced by costal cartilages. As shown in *Figure 25*, the upper seven costal cartilages articulate with the sternum. The next three are joined to the costal cartilage of the rib above, while the last two are known as "floating ribs," because they have no anterior attachment.

STERNUM

Figure 25 illustrates the anterior part of the thoracic cage, consisting of the sternum and its articulation with the costal cartilages. Observe that the sternum comprises three parts:

1. The thick, somewhat triangular *manubrium*, which has extensive notches for articulation with the first rib and with the medial end of the clavicle.
2. The *body* of the sternum, which develops from four separate elements called *sternebrae*. The site of union between adjacent sternebrae is marked by a raised transverse line.
3. The *xiphoid process*, the thin elongated termination of the sternum. Its form is extremely variable.

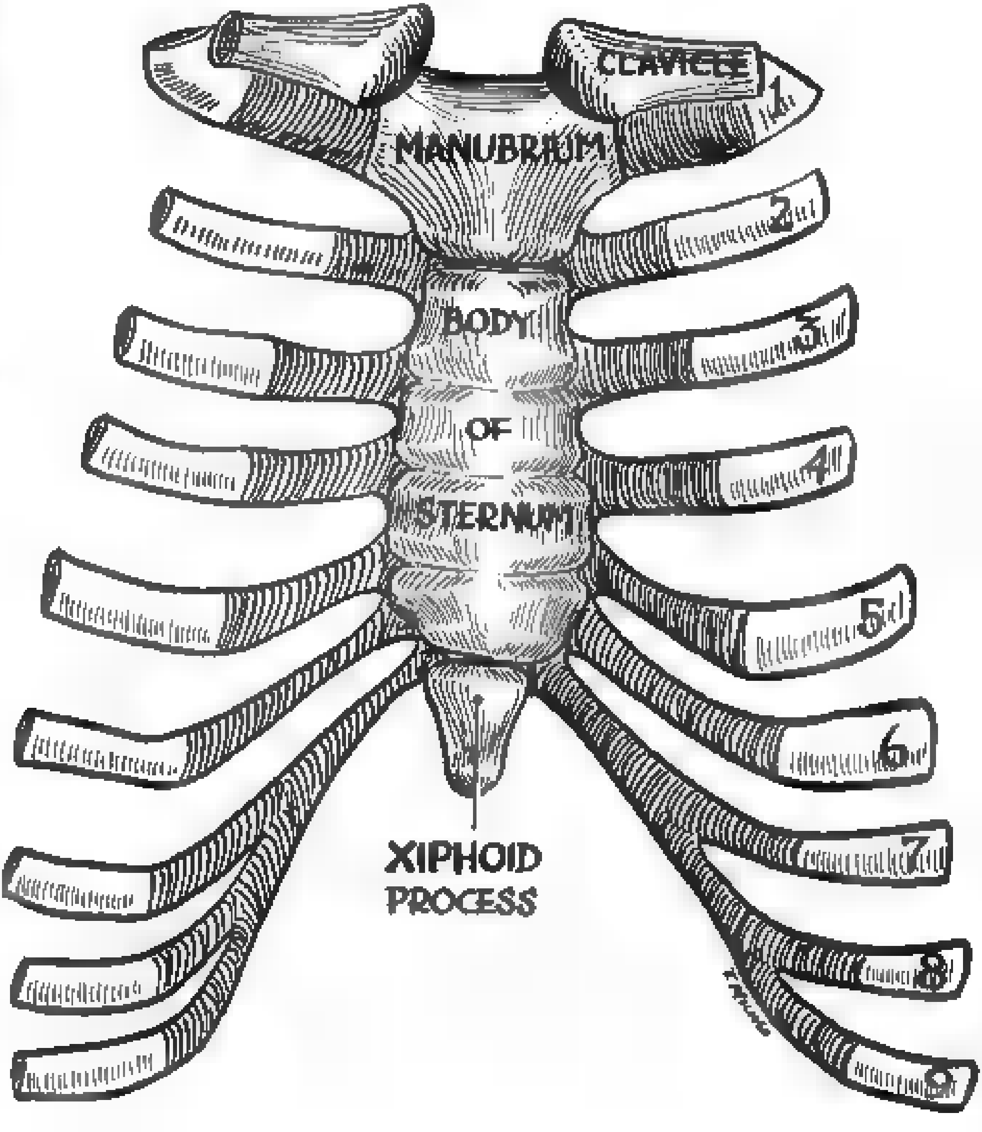

CLAVICLE
1
MANUBRIUM
2
BODY
3
OF
4
STERNUM
5
6
XIPHOID
PROCESS
7
8
9

Figure 25

CHAPTER VII

SKULL AND MANDIBLE

SKULL

The skull is [redacted] complex collection of bones which have fused together [redacted] form a protective container for the brain, the skeleton of the face, and the areas for muscle attachment. The region of contact between adjacent skull bones may be completely obliterated so that one bone blends imperceptibly into the next, or a line known as a suture may give evidence of the articulation.

In archaeological finds, the skull may be intact, or it may be in a number of fragments. This indicates how important it is to study the skull in considerable detail so that its parts may be recognized.

Figures 26, 27, and *28* show various views of the skull. Using these illustrations, study an actual skull, and note—

1. The bones of the cranium which form [redacted] container for the brain.
2. The delicate bones of the facial skeleton.
3. The relationship of bones to each other, their articulations, and the appearance of their sutures.

To gain a more detailed knowledge of the skull, [redacted] will now examine in some detail certain individual skull bones. It is assumed that each of these bones, although studied alone, will be considered as one part of the whole skull.

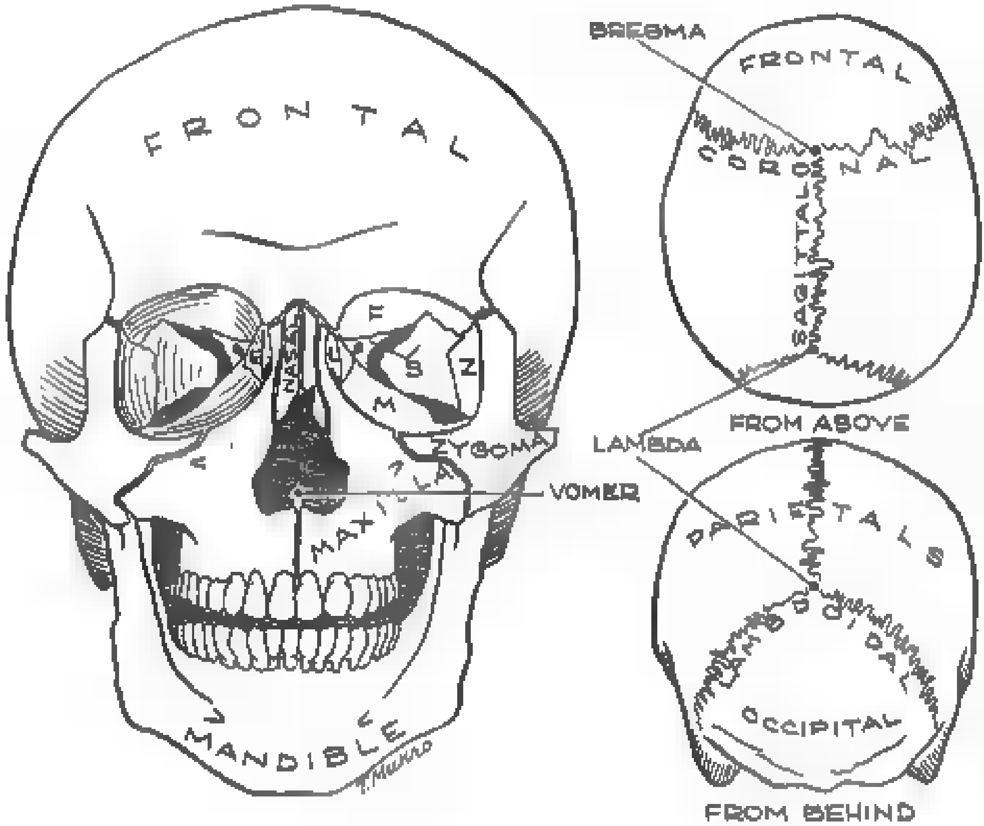

FRONTAL
NASAL
L
E
F
S
M
Z
ZYGOMA
MAXILLA
VOMER
MANDIBLE
BREGMA
FRONTAL
CORONAL
SAGITTAL
FROM ABOVE
LAMBDA
PARIETALS
LAMBDOIDAL
OCCIPITAL
FROM BEHIND

Figure 26

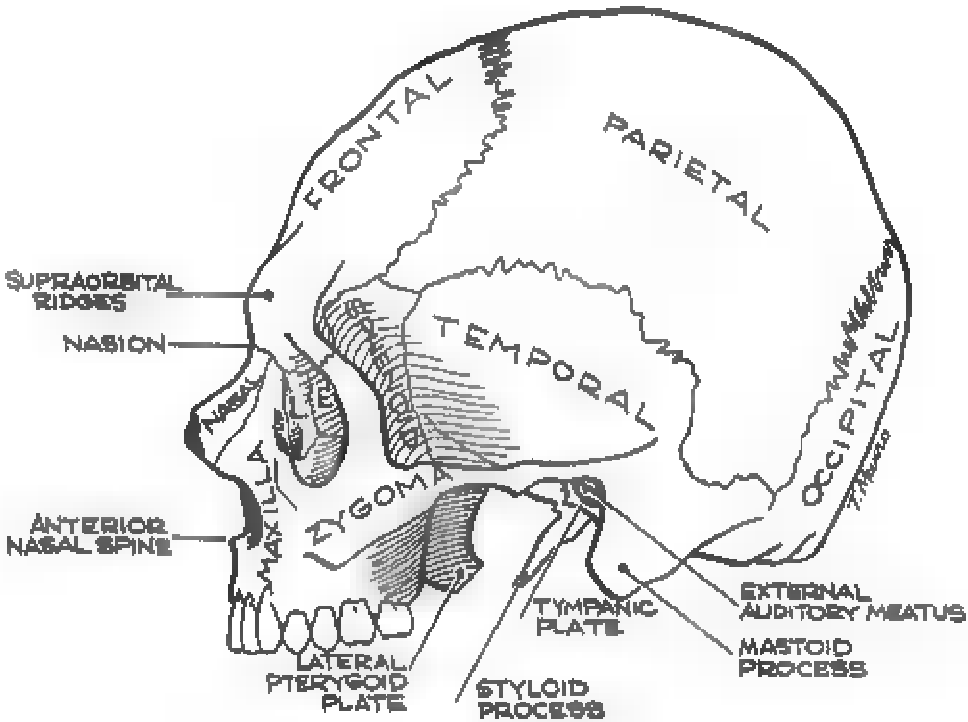

FRONTAL
PARIETAL
TEMPORAL
OCCIPITAL
SUPRAORBITAL RIDGES
NASION
NASAL
MAXILLA
ZYGOMA
ANTERIOR NASAL SPINE
LATERAL PTERYGOID PLATE
STYLOID PROCESS
TYMPANIC PLATE
EXTERNAL AUDITORY MEATUS
MASTOID PROCESS

Figure 27

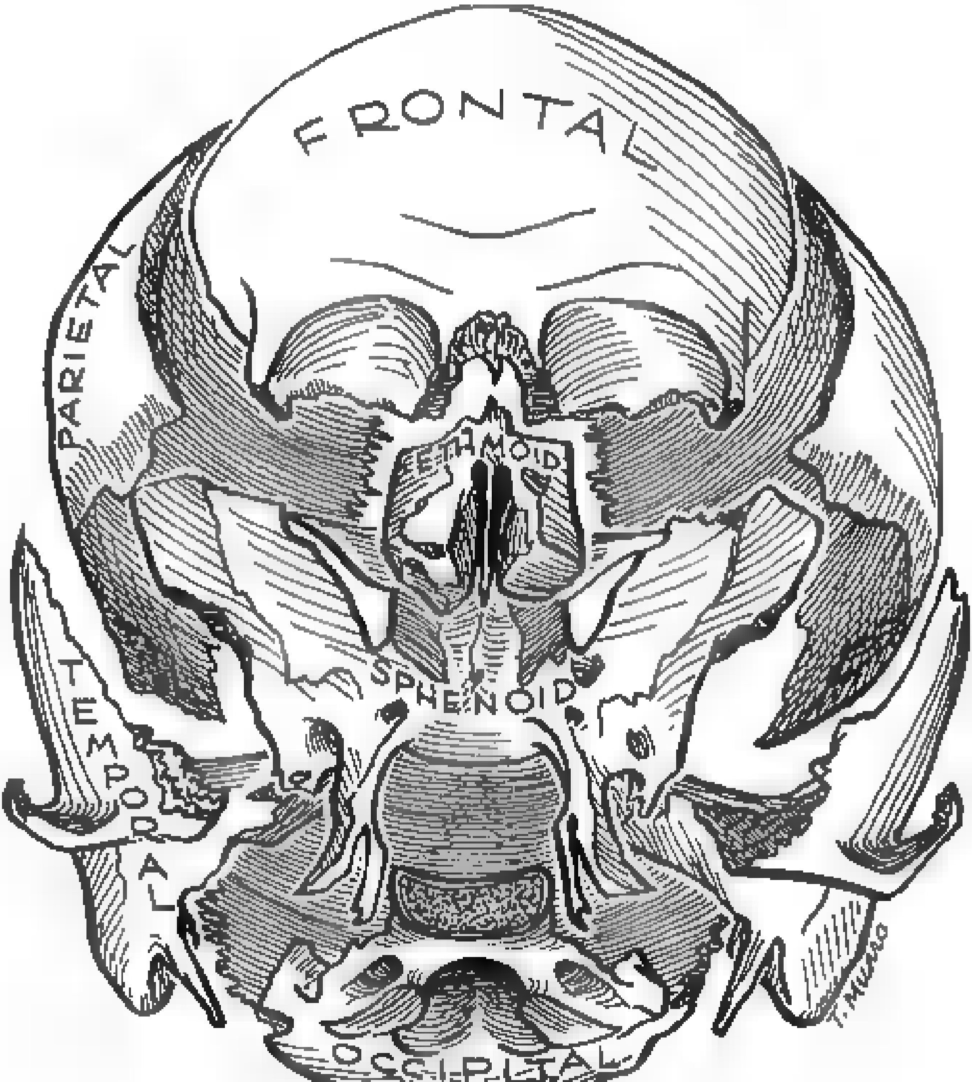

FRONTAL
PARIETAL
ETHMOID
SPHENOID
TEMPORAL
OCCIPITAL
T. MIAO

Figure 28

The frontal bone consists of two parts:

1. The *squamous* part completing the vault of the skull in front.
2. The *orbital plates* set on [redacted] angle to the squamous part and forming both a roof to the orbit and a floor to the anterior part of the brain.

Examine the frontal bone carefully, noting its relation to the intact skull and the bones with which it is in contact. Using *Figure 29* as a guide, identify the following:

A. *Orbital plates* (Feel how thin they are).

B. *Ethmoidal notch* (into which fits the ethmoid bone).

C. The *zygomatic process*, a strut forming one of three supports for the zygoma.

D. The *supraorbital notch* (Is it a canal, a notch, or a foramen on your specimen ?); through it passes a nerve and vessels.

E. The *frontal air sinuses* which hollow out the bone anteriorly.

F. The *temporal line* to which attaches Temporalis, a muscle that closes the jaw.

G. The *depression for the lacrimal gland*, which secretes tears into the orbit.

H. The *supraorbital or brow ridge* which varies in prominence between sexes and races.

I. The *glabella*, over which the skin is devoid of eyebrow (Glabrous=bald).

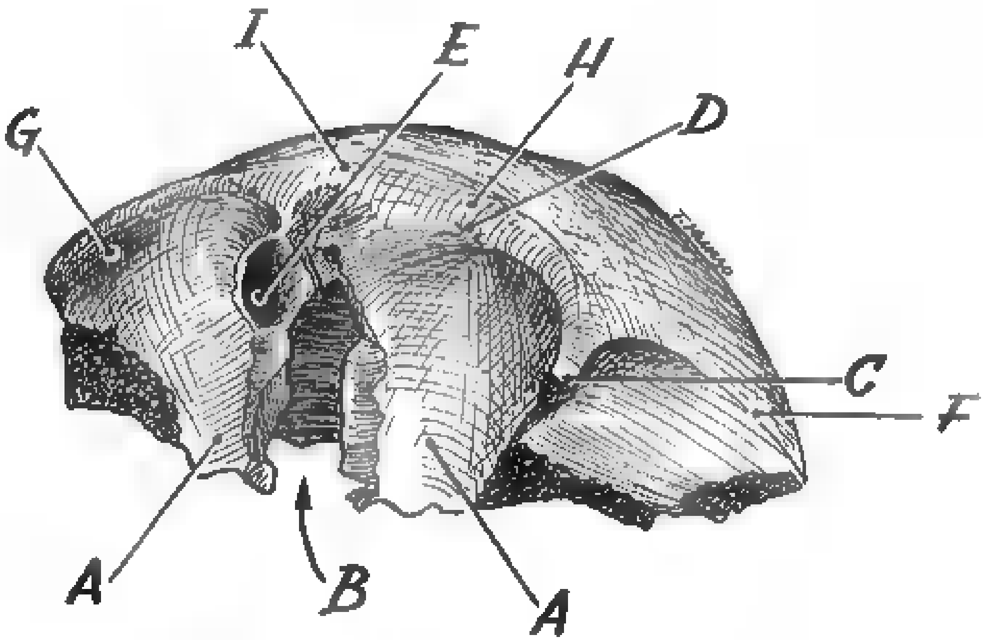


Figure 29

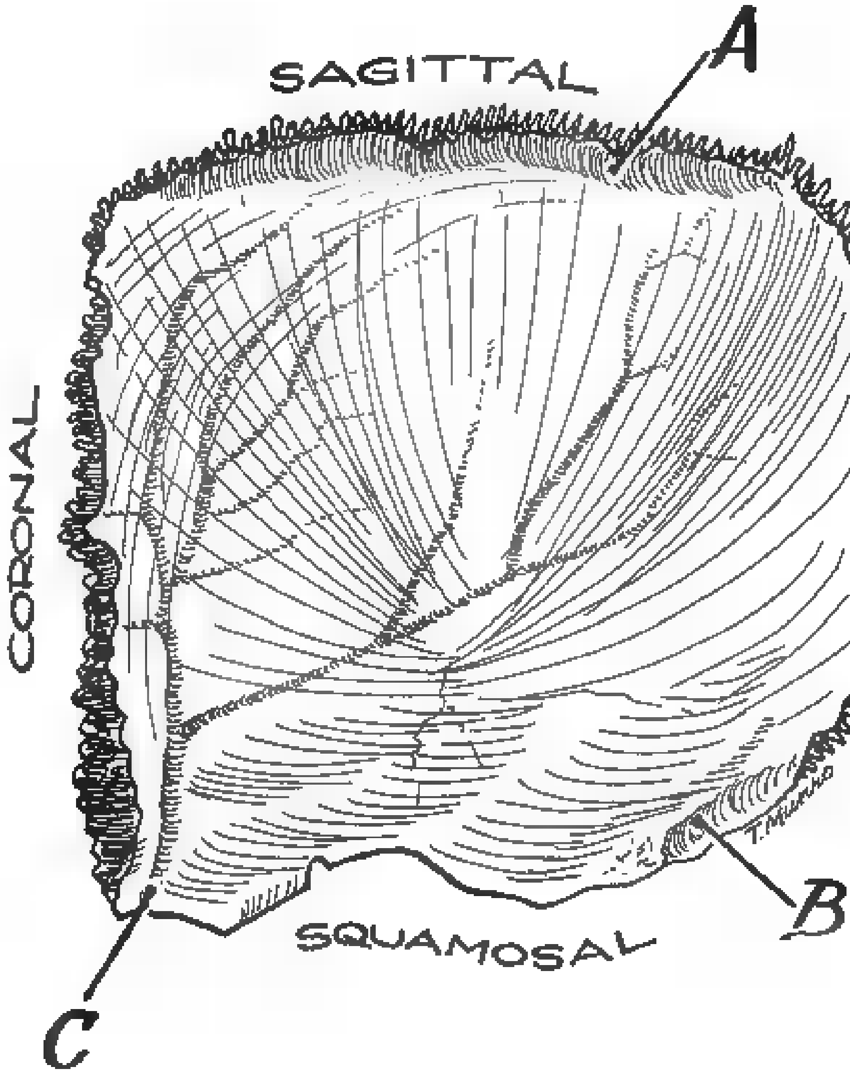


Figure 30

PARIETAL BONE

The parietal bone (*Figure 30*) is a curved, almost square bone which contributes largely to the formation of the skull vault.

Observe the following:

The parietal bone has four sides, each in contact with a different skull bone, and each contributing to the formation of a different suture or joint as follows:

1. The anterior side contacting the frontal bone at the *coronal suture*.
2. The medial side contacting the opposite parietal bone at the *sagittal suture*.
3. The lateral side contacting the temporal bone at the *squamosal suture*.
4. The posterior side contacting the occipital bone at the *lambdoidal suture*.

Each of the four angles of the parietal bone articulates with two other skull bones. The areas of contact have been given Greek names. Note also the shape of the angle formed, as this is of assistance in identifying skull fragments.

1. *Bregma* in contact with frontal and opposite parietal.
2. *Pterion* in contact with frontal and sphenoid.
3. *Lambda* in contact with occipital and opposite parietal.
4. *Asterion* in contact with occipital and mastoid part of temporal.

Consulting *Figure 30*, note the following features:

A. A groove for the superior sagittal [redacted] sinus.
B. A groove for the sigmoid venous sinus.
C. The intricate groove for the middle meningeal vessels.

OCCIPITAL BONE

Study the occipital bone in conjunction with *Figure 31*, locating all features mentioned.

1. Outer Surface

A. The *inion,* or external occipital protuberance. It may appear as a lump or a ridge.

B. The *superior nuchal line.* "Nuchal" refers to the neck, and to this line muscles attach.

C. The *external occipital crest.*

D. The *foramen magnum,* through which passes the spinal cord.

E. The *occipital condyles,* which transmit the weight of the skull to the atlas.

F. The *anterior condylar canal,* for the hypoglossal nerve.

G. The *jugular process,* which projects laterally in the region of the condyles and is somewhat reminiscent of the transverse processes of a vertebra.

2. Inner Surface

H. The deep grooves for the *superior sagittal venous sinus* and the two

I. *transverse sinuses,* right and left.

J. The *internal occipital crest.*

Note the areas of the occipital bone in contact with *parietal, temporal,* and *sphenoid* bones.

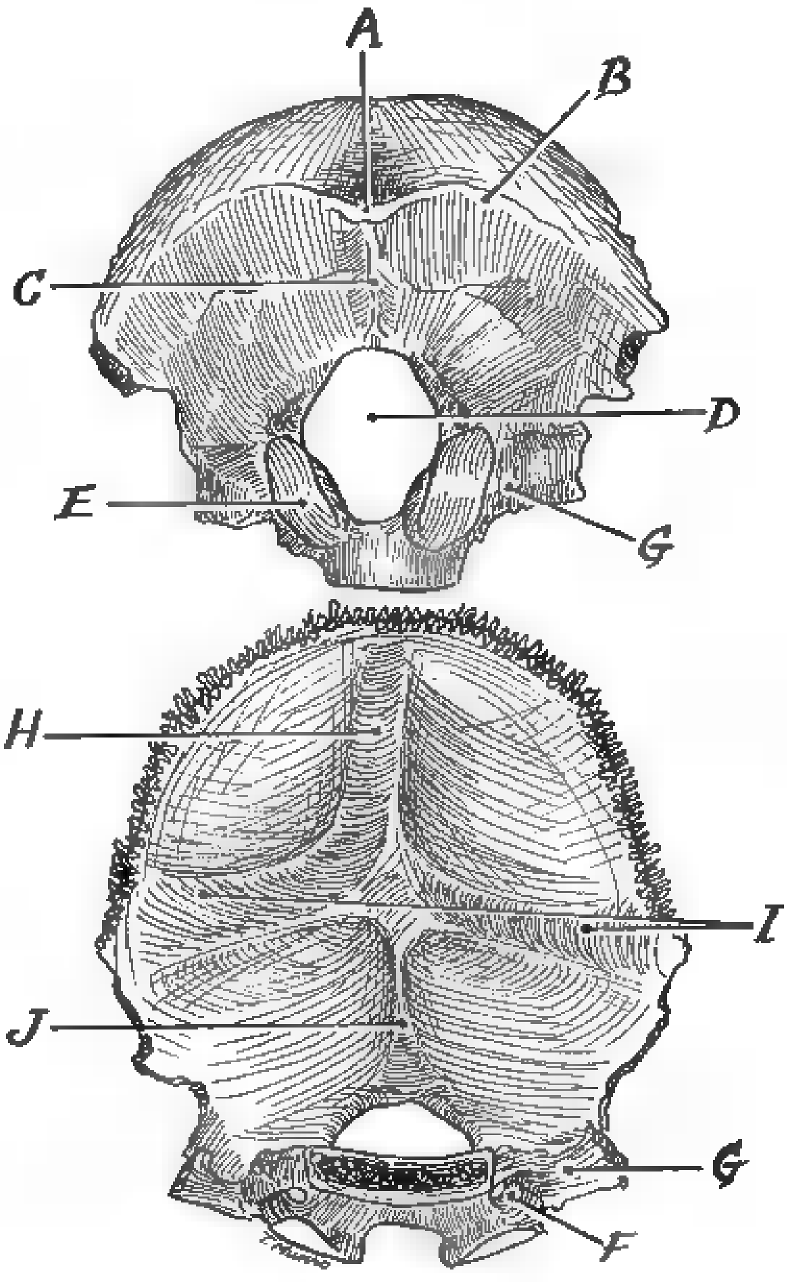


Figure 31

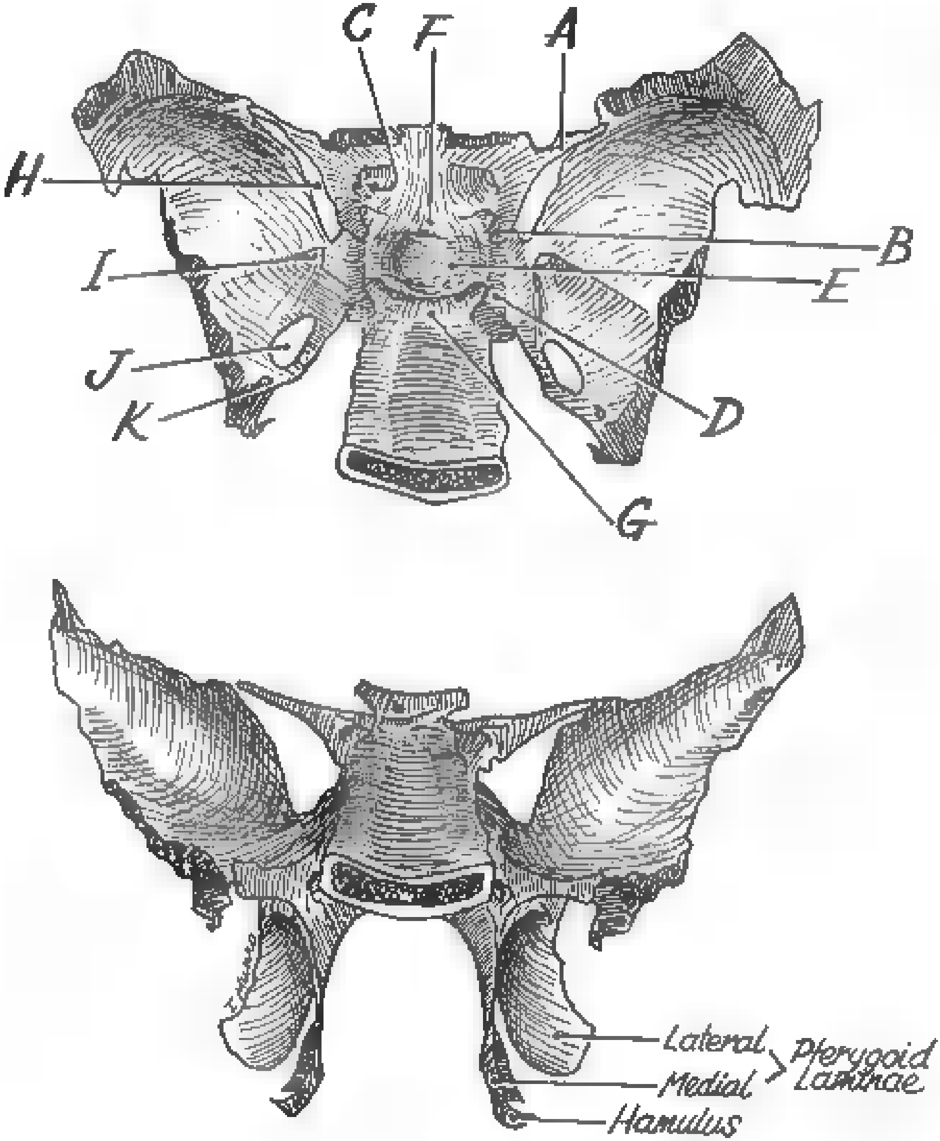


Figure 32

SPHENOID BONE

Notice that the sphenoid bone resembles a bat whose body is the body of the sphenoid, whose wings are the greater and lesser wings of the sphenoid, and whose legs are the pterygoid processes.

The following parts of the sphenoid bone are labelled in *Figure 32:*

A. The *lesser wing,* which is in contact in front with the ethmoid bone and with the orbital plates of the frontal bone.

B. The *anterior clinoid processes,* which are little prolongations backwards from the lesser wing.

C. The canal named the *optic foramen,* which is bounded by the lesser wing, the anterior clinoid, and a little root from the body of the sphenoid. Through this canal passes the optic nerve and the ophthalmic artery, which supply the eyeball.

D. The groove on the side of the body for the internal carotid artery.

E. The depression [illegible] the upper surface of the body: the *pituitary fossa.* In it lodges the pituitary gland.

F. The swelling in front of this fossa, named the *tuberculum sellae* ("lump of the saddle").

G. *The dorsum sellae* ("back of the saddle"), which terminates above and laterally in the posterior clinoid processes.

There is a crescent of foramina in the greater wing of the sphenoid, each of which transmits nerves and vessels:

H. *Superior orbital fissure,*

I. *Foramen rotundum,*

J. *Foramen ovale,* and

K. *Foramen spinosum.*

Identify the areas of the sphenoid which articulate with the following other skull bones: *ethmoid, frontal, parietal, squamous part of temporal*, and *occipital.*

The medial and lateral pterygoid plates or laminae are seen at the base of the skull. See how the medial pterygoid is slender and terminates in [redacted] hook, the *hamulus.* The lateral pterygoid lamina is broad for the attachment of the pterygoid muscles to its inner and outer sufaces.

TEMPORAL [redacted]

The temporal bone consists of four parts:

1. The thick *mastoid process.*
2. The flat *squamous part.*
3. The scroll-like *tympanic plate.*
4. The long rock-like *petrous part.*

Notice that the temporal bone articulates with three bones: occipital, sphenoid, and parietal.

The outer surface of the temporal bone shows the following features, as labelled in *Figure 33.*

A. The *squamous part* with its oblique overlapping suture on the inner surface of its free edge.

[redacted]. The slender *zygomatic process* which forms [redacted] of the three struts supporting the zygoma.

C. The *mastoid process* which contains air cells and affords attachment to the sterno-mastoid muscle. On its inner surface is the *digastric groove.*

D. The *tympanic plate,* [redacted] flat thin bone forming part of the scroll enclosing the external auditory meatus behind and bounding the mandibular fossa in front. The mandibular fossa accommodates the condyle of the mandible.

E. Projecting from behind the tympanic plate is the *styloid process,* at whose root you should find the tiny *stylomastoid foramen.* Through this hole passes the 7th cranial nerve.

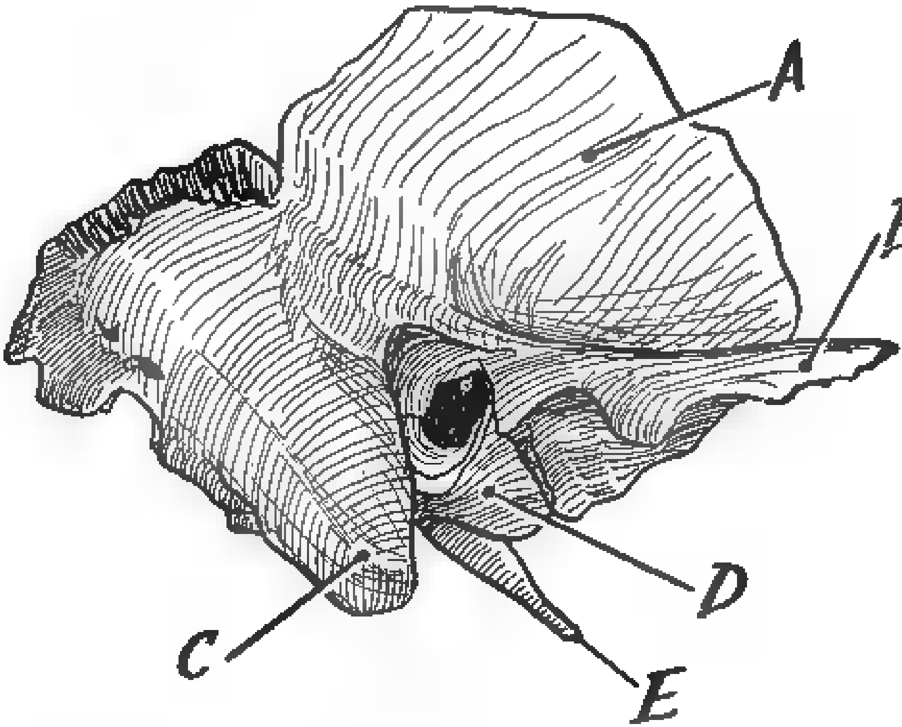


Figure 33a

The inner surface of the temporal bone shows the following features:

F. The very deep groove for the *sigmoid venous sinus*. (It is shaped like a Greek sigma.)

G. On the petrous part of the temporal bone the *internal auditory meatus* through which cranial nerves 7 and [redacted] leave the cranial cavity.

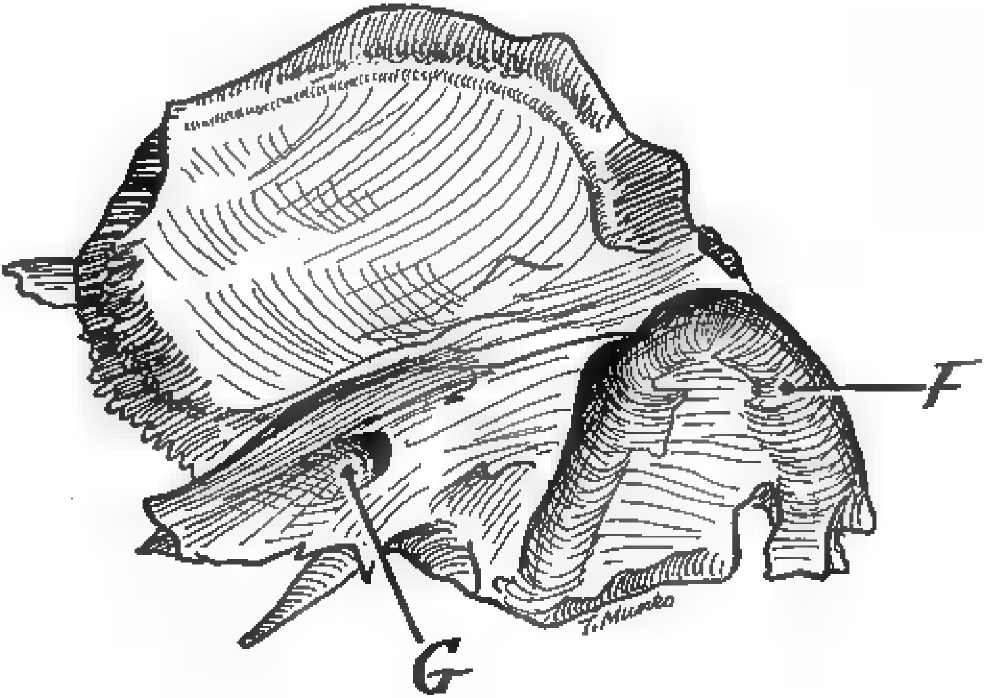


Figure 33b

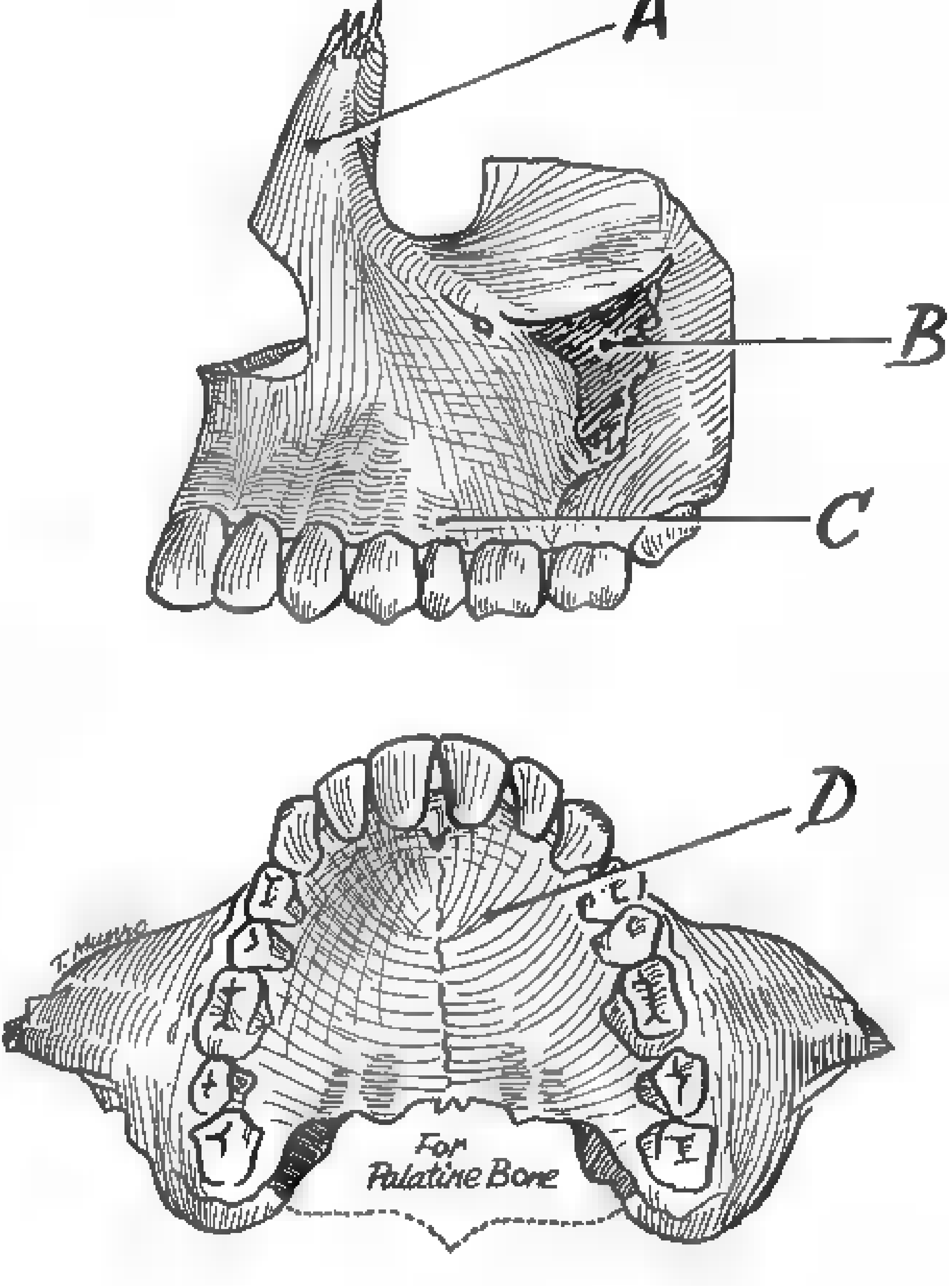


Figure 34

MAXILLA

Figure 34 shows that the maxilla consists of [redacted] body (containing the maxillary sinus or antrum) with four processes *extending from it:*

A. The *frontal process,* which has three areas of contact with bone: anterior border with *nasal,* posterior border with *lacrimal,* and superior border with *frontal.*

B. The *zygomatic process*—Notice its broad triangular base.

C. The *alveolar process,* which bears the teeth. The rounded posterior extremity is called the *maxillary tuberosity.*

D. The *palatine process* forms the greater part of the hard palate. Above, it forms part of the floor of the nasal cavity; below, part of the roof of the mouth.

Note that the hard palate is formed mainly by the palatine process of the maxillae. The horizontal plate of the palatine bone forms the posterior one-quarter. Anteriorly on the palate is the *incisive foramen;* posteriorly, [redacted] the paired greater and lesser *palatine foramina.*

MANDIBLE

Using *Figure 35* as a guide, study the mandible noting the following features:

A. The *ramus* of the mandible.

B. The *head* or *condyle*, which articulates with the skull in the mandibular fossa, forming the jaw joint.

C. The *coronoid process*, which gives attachment to the lower end or insertion of the temporalis muscle, a strong muscle of mastication.

D. The *mandibular notch* between the coronoid process and the condyle.

E. The *lingula*, a tongue-like process which guards

F. the *mandibular foramen*, which transmits a nerve and vessels to the interior of the mandible.

G. The *mylo-hyoid groove*.

H. The *mylo-hyoid line* for attachment of the muscle of the same name which helps to form the floor of the mouth.

I. The body of the mandible, which has a dense lower part, and a less dense *alveolar* part which bears the teeth.

J. The *mental foramen*, through which passes the nerve of the same name.

The two halves of the jaw are fused together in the midline at the *symphysis menti*. Near this joint on the inner surface of the mandible are two small pairs of *genial tubercles*, the upper pair of which gives attachment to certain muscles of the tongue.

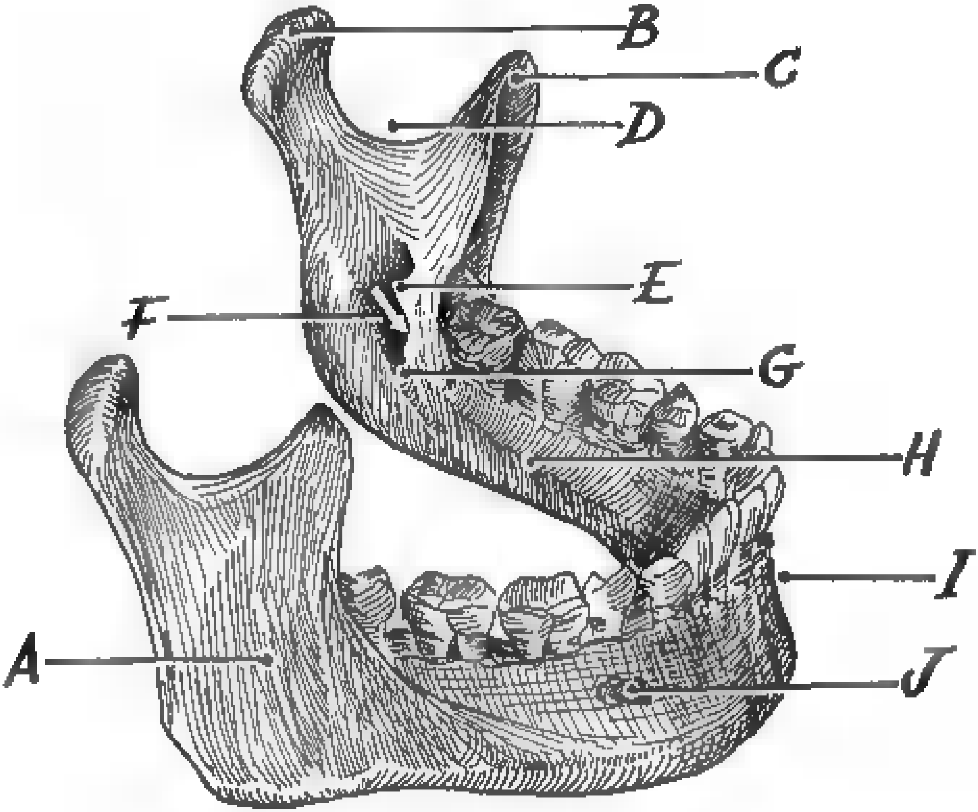


Figure 35

CHAPTER VIII

THE DENTITION

To the archaeologist and anthropologist, a knowledge of the dentition is of considerable importance. Because of the hard structure of the teeth they are the most stable elements of the human body, remaining intact even after long years of burial in the ground. Also, because of their response to functional change and their reaction to genetic influence, the teeth provide extremely valuable morphological information. Indeed, much of our early knowledge of man's origin was based on a study of the dentition in fossil man and the primates.

A tooth consists of a *crown*, which is visible in the mouth, and a *root*, which [redacted] buried in the bone and soft tissue of its socket. The crown is covered with *enamel;* the root with *cementum*. The interior of the tooth is composed of a soft substance called the pulp, which is within the pulp cavity and is surrounded by [redacted] thick layer of *dentine*. At the apex of the root is a small hole which transmits vessels and nerves to the interior of the tooth.

Because of the arch-like arrangement of the dentition it is necessary to adopt a different set of anatomical terms for describing the surfaces and positions of the teeth. *Mesial* denotes proximity to the median plane of the dental arch, which passes between the two central incisors. *Distal* refers to distance from this plane. For example, the molars are distal to the incisors, which, in turn, are mesial to the premolars.

A tooth has five surfaces:

1. The *occlusal* surface is the area in contact with the similar surface of a tooth above or below. It is the biting surface.
2. The *buccal* surface is on the cheek side of the tooth.
3. The *lingual* surface is on the tongue side of the tooth.
4. The *distal* surface is farthest from the median plane of the dental arch.
5. The *mesial* surface is the closest to this plane.

Examine the dentition in an intact jaw, and locate each of these surfaces.

THE PERMANENT DENTITION

The secondary or permanent dentition consists of thirty-two teeth. These may be grouped according to form. In each half of the jaw there are eight teeth consisting of—

Two INCISORS, a medial and a lateral: spade-like biting teeth;

One CANINE, a tusk-like tooth;

Two PREMOLARS, or bicuspids, which bear two cusps on their occlusal surfaces;

Three MOLARS, which bear three to six cusps. As a general rule, upper molars have three roots, and lower molars two.

Figure 36 illustrates these four types of teeth.

The number and disposition of the teeth are usually expressed in the *Dental Formula*. For instance, the primary dentition of man is

$$I\frac{2}{2} \qquad C\frac{1}{1} \qquad PM\frac{2}{2} \qquad M\frac{3}{3}$$

This is a shorthand expression of the fact that there are two incisors, one canine, two premolars, and three molars in both upper and lower jaws on each half of the dental arch.

Because of the hazards of the excavation process and the vagaries of burial practices, the archaeologist is frequently faced with the problem of identifying individual loose teeth. To assist in so doing, the following key is appended:

Stage one consists of determining the type of tooth: incisor, canine, premolar, or molar. Referral to the above text and illustration will render this a comparatively easy task.

Stage two involves the decision of whether the tooth in question is from the upper (maxillary) or lower (mandibular) dentition.

Stage three locates the tooth within its own group—central or lateral incisor; first or second premolar; first, second, or third molar.

Stage four determines whether the tooth belongs to the right or left arches.

Stages two, three, and four will now be dealt with systematically.

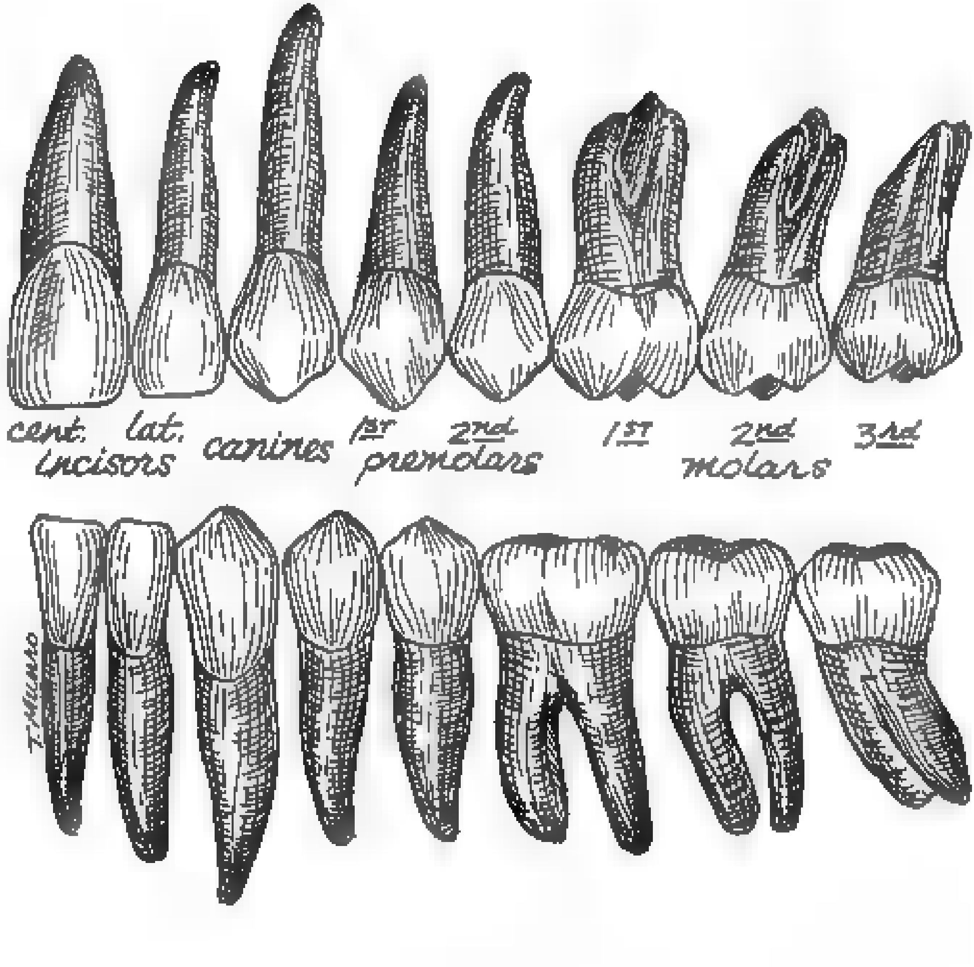

cent. lat.
incisors
canines
1st 2nd
premolars
1st 2nd 3rd
molars

Figure 36

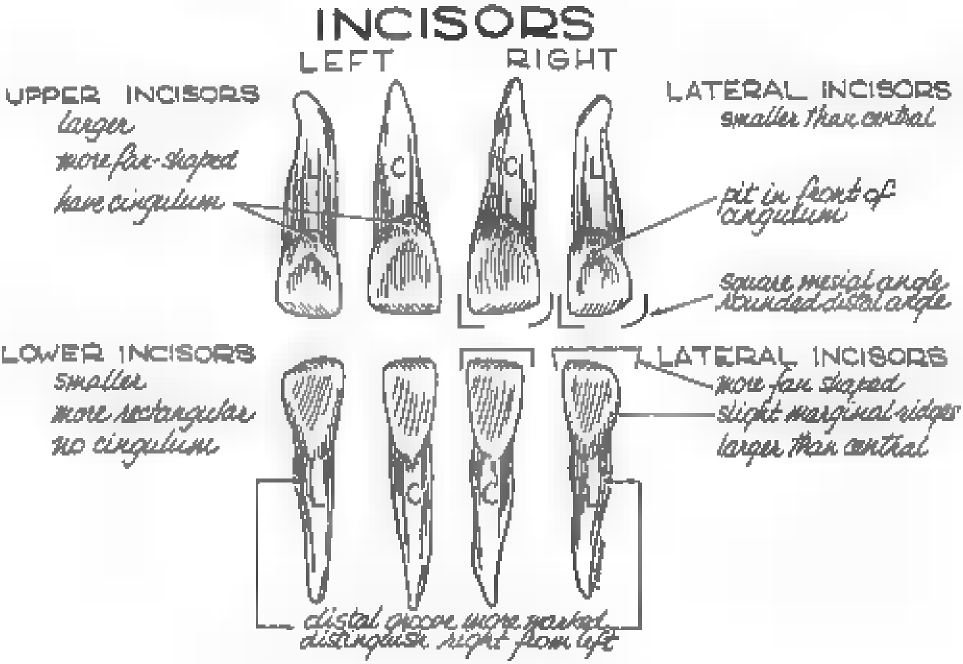

INCISORS
LEFT
RIGHT
UPPER INCISORS
larger
more fan-shaped
have cingulum
LATERAL INCISORS
smaller than central
pit in front of cingulum
square mesial angle
rounded distal angle
LOWER INCISORS
smaller
more rectangular
no cingulum
LATERAL INCISORS
more fan shaped
slight marginal ridges
larger than central
distal groove more marked
distinguish right from left
L
C
C
L
L
C
C
L

Figure 37

INCISOR TEETH

(*See Figure 37*)

A. Distinguish upper from lower incisors—

—	Upper	Lower
Size	Large	Small
Shape	Spade-like	Narrow
Marginal ridges	Well-marked	Absent or slight
Cingulum	Present	Not present

The cingulum is a bulge on the lingual surface of the tooth [redacted] its neck. It is present on maxillary incisors, but no well-marked cingulum may be noted on mandibular incisors.

B. Distinguish central from lateral incisors—

Upper: (*a*) The central upper incisor is larger.

(*b*) The lateral upper incisor has a pit in front of the cingulum.

Lower: (*a*) The lateral incisor is larger than the central.

(*b*) The lateral incisor has a slightly more fan-shaped crown and very slight marginal ridges.

C. Distinguish right from left—

Upper: The angle between the distal edge and the incisive edge is rounded, while the angle between the mesial edge and the incisive edge is a right angle.

Lower: The roots of the lower incisors are flattened in a mesio-distal plane and grooved on their flattened surfaces. The distal groove is most marked and [illegible] acts as an indicator for determining right from left.

CANINE TEETH

(*See Figure 38*)

A. Distinguish upper from lower canines—

Upper	Lower
Wide crown	Narrower crown
Sharp point [illegible] cusp	Blunt point on cusp
Marked cingulum	No cingulum

B. Distinguish right from left—

In examining the outline of the occlusal edge, it is found that the mesial slope is shorter.

CANINES

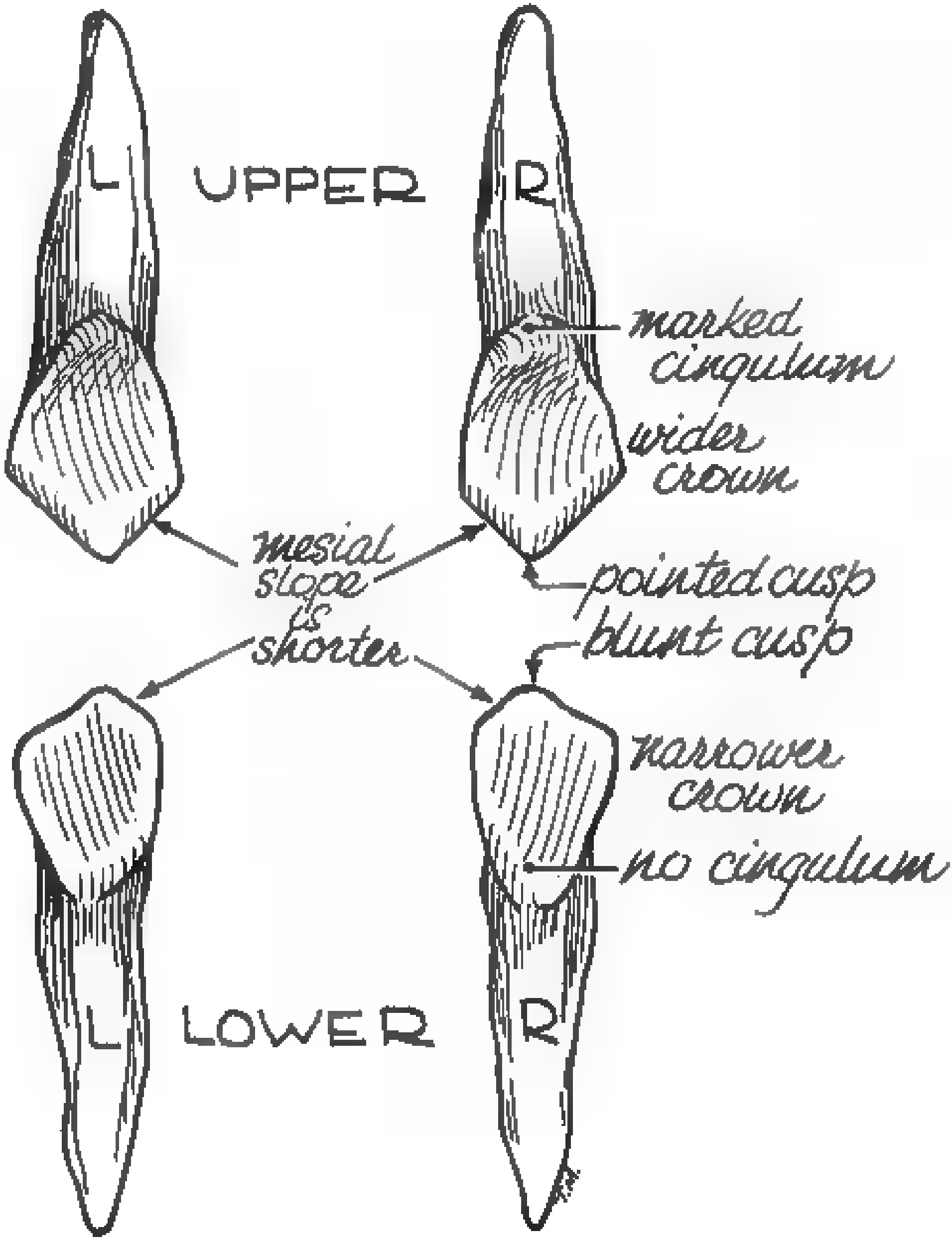


Figure 38

PREMOLARS

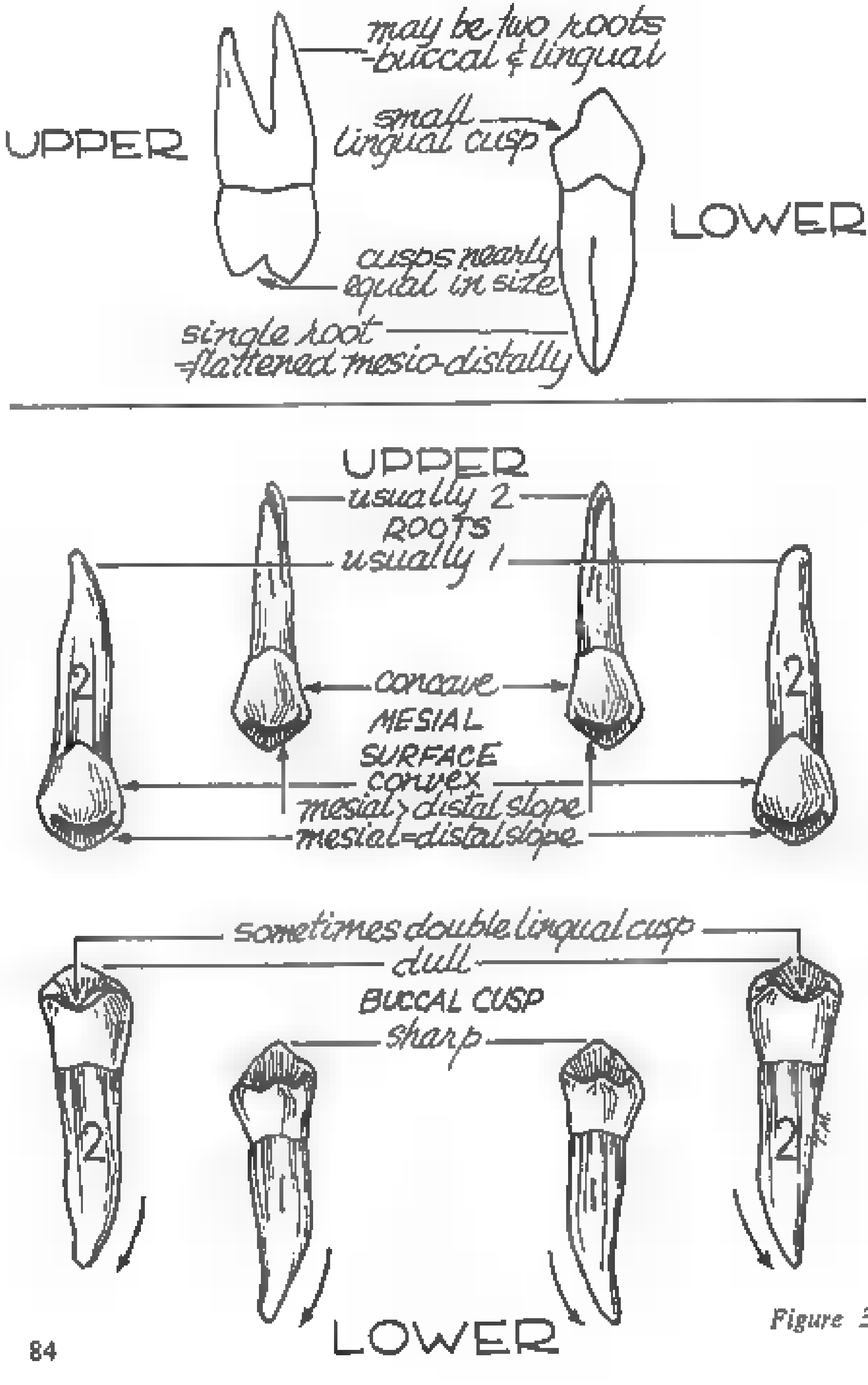


Figure 39

PREMOLAR TEETH

(*See Figure 39*)

A. DISTINGUISH UPPER FROM LOWER—

—	Upper	Lower
Cusps	More nearly equal in size	Lingual cusp small, may be double on 2nd
Roots	May be 2: buccal and lingual	Single, with mesiodistal flattening. Often curved distally

B. DISTINGUISH FIRST FROM SECOND—

(*a*) *Upper*

—	First	Second
Cusps	Buccal is larger	Equal in size
Slope of buccal cusp	Mesial is longer	Equal slopes
Roots	Usually 2	Usually 1
Mesial surface	Concave	Convex

(*b*) *Lower*

—	First	Second
Lingual cusp	Small	Sometimes double, the mesial being larger than the distal
Buccal cusp	Sharp point	Duller point

C. DISTINGUISH RIGHT FROM LEFT—

From information given above, determine

(*a*) Buccal and lingual surfaces,

(*b*) Mesial and distal surfaces,
then locate in the dental arch.

MOLAR TEETH

(*See Figure 40*)

A. DISTINGUISH UPPER FROM LOWER—

—	Upper	Lower
Number of roots	3 roots or 3 roots fused	2 roots or 2 roots fused
Arrangement of roots	Lingual Mesio-buccal Disto-buccal	Mesial Distal
Shape of crown	Rhombic	Oblong
Number of cusps	Usually 4 or [illegible]	Usually 5 or 4
Cusp pattern when [illegible] cusps present	Usually asymmetrical	Usually cruciate division between cusps

B. Distinguish between first, second, and third—

(a) Upper

—	First	Second	Third
The lingual root	The largest; widely divergent	Not so widely diverged	Roots often fused
Cusps	4 well marked. Disto-lingual is smallest.	Disto-lingual cusp is reduced in size or absent. 66%: 4 cusps 32%: 3 cusps 2%: other	Cusp pattern variable 37%: 4 cusps 50%: 3 cusps 5%: 2 cusps 8%: other
Carabelli's tubercle	Present in 60%	Sometimes present when found on first molar.	Absent
Contact facets	Mesial and distal for contact with PM2 and M2	A mesial facet is usually present denoting contact with M1.	A mesial facet may be present.

(b) Lower

—	First	Second	Third
Roots	The two roots are discrete, the mesial being curved backwards.	The two roots are sometimes fused; both are curved backwards.	The two roots are often fused and curve backwards.
Cusps	Usually 5 cusps, a distal cusp being added. 82%: 5 cusps 14%: 4 cusps 4%: other	Usually 4 cusps, the distal being lost. 69%: 4 cusps 29%: 5 cusps 2%: other	Many irregularities 46%: 5 cusps 37%: 4 cusps 17%: other
"Dryopithecus pattern"	75%	25%	Rare

The "Dryopithecus pattern" is described in Chapter IX on Dental Observations.

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C. Distinguish right from left—

Upper teeth: (*a*) There is a more marked convexity on the lingual surface.

(*b*) The smallest cusp is the disto-lingual.

Lower teeth: (*a*) There is a more marked convexity on the buccal surface.

(*b*) The 5th cusp, when present, is distal.

THE PRIMARY DENTITION

The dental formula of the primary, deciduous, or milk dentition is

$$i\frac{2}{2} \qquad c\frac{1}{1} \qquad m\frac{2}{2}$$

Primary teeth differ from the permanent teeth which succeed them in the following characteristics:

Size:	smaller
Crown:	more bulbous
Roots:	shorter, more delicate, more divergent
Neck:	the cemento-enamel junction is more constricted
Colour:	whiter

Comparison of primary and permanent teeth is shown in *Figure 41*.

The eruption of the dentition will be considered in the section [illegible] age determination.

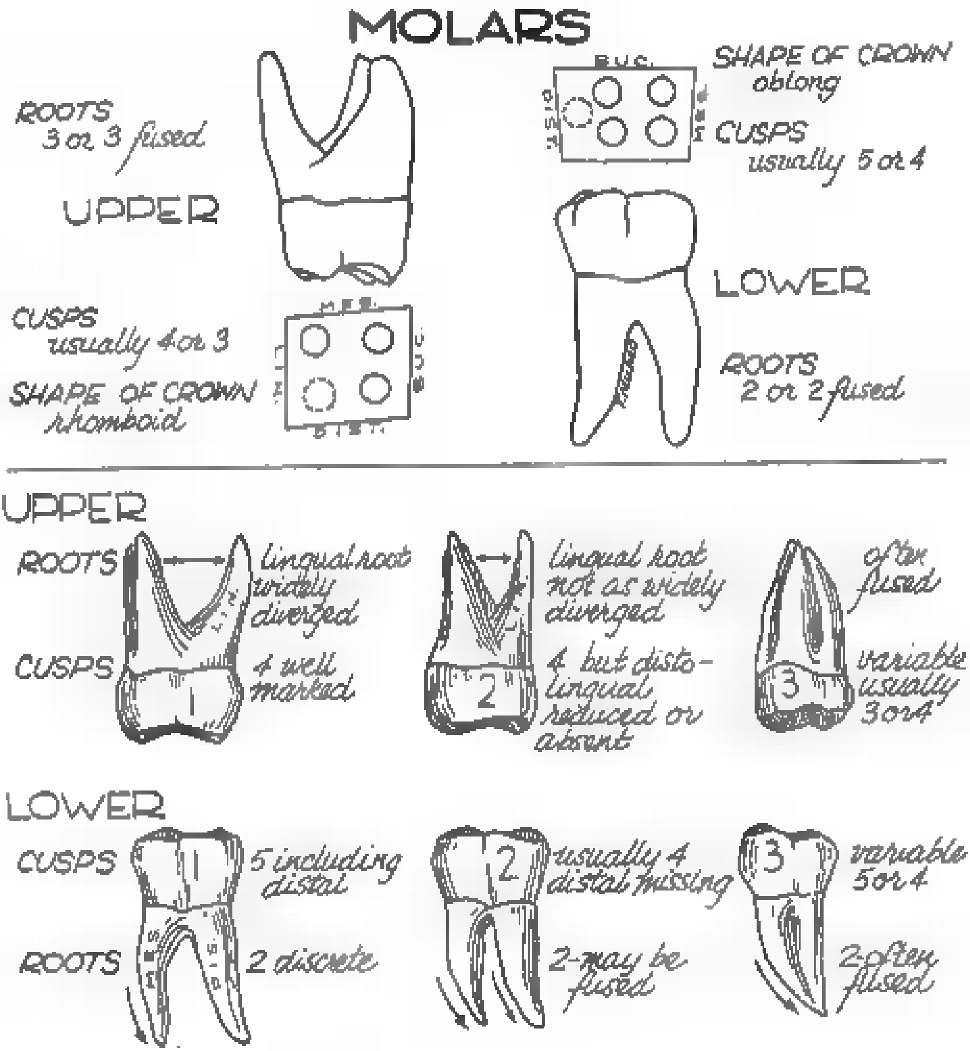

Figure 40

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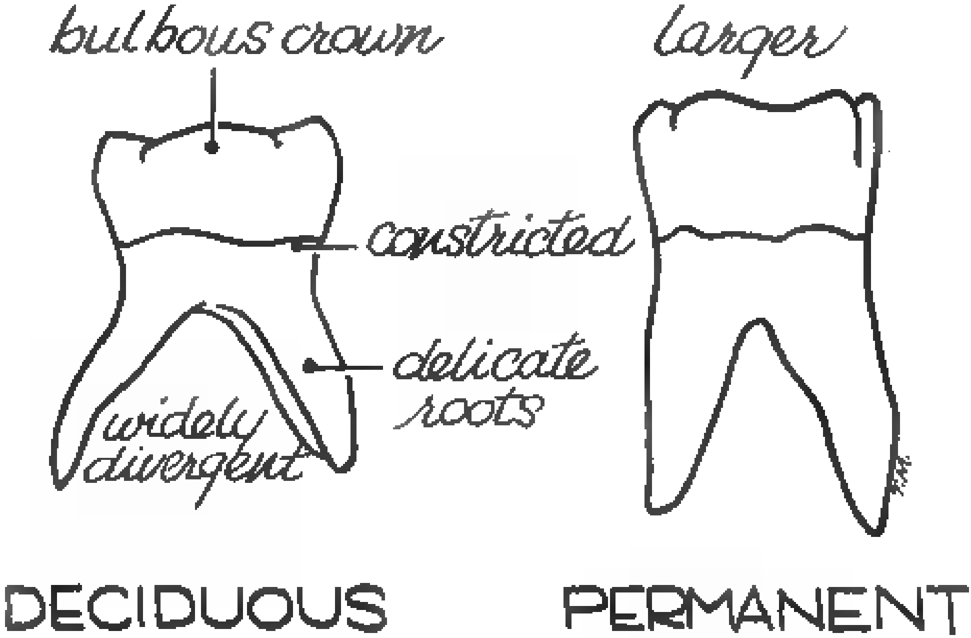

Figure 41

CHAPTER IX

DENTAL OBSERVATIONS

Having gained [redacted] general knowledge of the appearance, arrangement, and eruption of the human dentition, we now proceed to note variations from what we have come to consider the "normal" pattern. These variations may be due to genetic influence, functional stresses, or pathological processes. In each of these cases, the observations made will contribute substantially to our understanding of the individual being studied.

1. *The size of teeth*

The details of odontometry (the measurement of the size of teeth) fall outside the scope of this book. In the bibliography, references are cited for comparative data on the subject.

It is noteworthy that the largest teeth in modern [redacted] are those of Australian Aborigines and Eskimos, while the smallest are found in African Bushmen and Laplanders. Evolutionary trends appear to be toward diminution of the size of the teeth. This is particularly obvious in modern human canines, in mere vestiges of the tusk-like teeth of the anthropoid apes, and even in fossil men. The third molar becomes increasingly smaller and is sometimes rudimentary. In most examples of modern man, the three molar teeth decrease in size from mesial to distal. However, in the African Bantu and sometimes in the Eskimo, this order is reversed, the third molar being the largest. This state is also found in some types of fossil man, in Australopithecus, and in Dryopithecus. In most of the living anthropoid apes, the second molar is the largest, followed by the third, then the first.

2. *The number of teeth*

The usual human dental formula [redacted] sometimes changed because of *congenital absence* of teeth [redacted] the presence of *supernumerary teeth*.

The commonest congenital absence is that of the third molar, although any of the teeth may be missing. The absence of a mandibular incisor is said to be much more common in Mongoloids than in any other racial group.

A third premolar or a fourth molar is sometimes present in the dentition. Additional abnormal *peg-shaped incisors* are found occasionally, particularly in the maxilla. Other abnormal supernumerary teeth, whose occlusal surfaces consist of a central pit surrounded by a marginal ridge, are sometimes found.

Since these abnormalities of number are genetically determined, it is not surprising that a racial difference in incidence has been noted. Studies have shown the lowest incidence of supernumerary teeth to be in White populations, while the highest reported is in the Bantu.

3. *Tooth form*

Numerous variations in the form of the teeth may be observed. The incisors, especially the lateral, may be *peg-shaped*. In Mongoloids, the incisors appear *shovel-shaped* because of marked mesial and distal ridges on their lingual surface. A small cusp-like projection called the *tuberculum dentale* may be seen on the lingual surface of maxillary incisors.

Taurodontism is a term applied to teeth in which there is elongation of the undivided region of the root with an accompanying large, deep pulp cavity. This form has been observed in Neanderthal fossil man and also in certain African groups. Some degree of taurodontism is seen in the molars of Mongoloids.

Carabelli's tubercle is a small cusp sometimes present on the lingual surface of the maxillary first molar and less frequently on the second. Its shape is variable, but it is usually cuspoid or globular. This tubercle is less common in Mongoloids than in other groups.

4. *Abnormalities of enamel*

Defects of the enamel may be observed on certain teeth whose surfaces appear pitted. Extensions of the enamel may be seen in some teeth spreading from the crown to the root area. These *enamel extensions* are a feature of the Mongoloid dentition. Ninety per cent of Mongoloid first maxillary molars show enamel extending between the two buccal roots. Tiny islands of enamel, termed enamel pearls, sometimes occur.

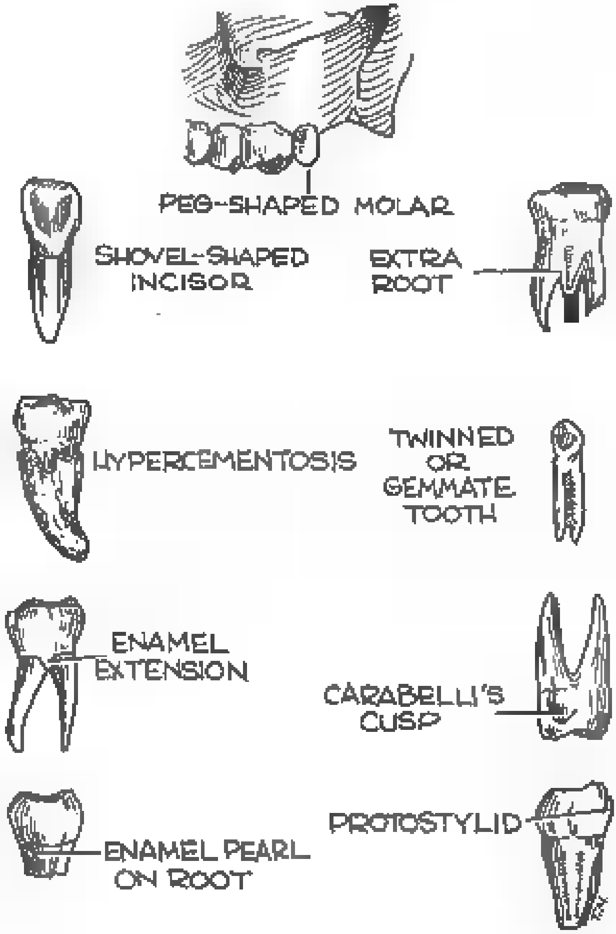
PEG-SHAPED MOLAR
SHOVEL-SHAPED INCISOR
EXTRA ROOT
HYPERCEMENTOSIS
TWINNED OR GEMMATE TOOTH
ENAMEL EXTENSION
CARABELLI'S CUSP
PROTOSTYLID
ENAMEL PEARL ON ROOT

Figure 42

5. *Hypercementosis*

This is the term applied to the excess formation of secondary cementum in the root area of a tooth. It is produced [redacted] a reaction to various conditions such as continued eruption of a tooth, malocclusion, injury, and infection. The extra cementum may appear [redacted] a bulbous mass around the apex of the root, [redacted] asymmetrical layer on one side of the root, or as small isolated spicules.

6. *Attrition*

Wear of the occlusal surface of the teeth is a normal consequence of use and increases with age. The degree of attrition depends also on the consistency of the diet. The teeth of primitive peoples existing in a hunting and gathering economy show marked wear owing to the rough character of their food, while the dentition of people existing on modern, soft, high carbohydrate diets shows little attrition. The degree of attrition varies from flattening of the occlusal surface of the cusps to loss of enamel with uncovering of dentine and even exposure of the pulp cavity.

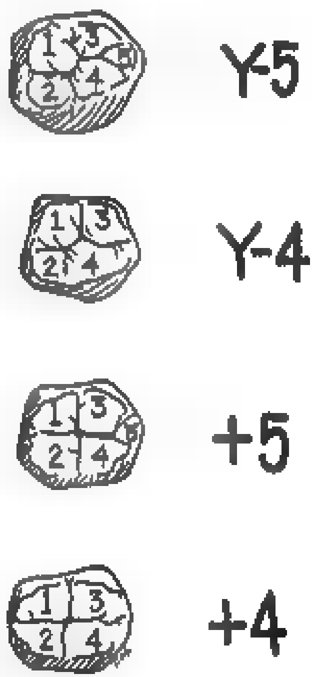

Figure 43

7. *Occlusion*

This is the term applied to the relationship of the teeth of the upper dental arch to those of the lower arch when the occlusal surfaces are in contact. The normal occlusion may be distorted by many factors which include tooth loss, excessive wear, and disproportion of teeth and jaws.

8. *Molar cusp pattern*

It has already been noted that there is a wide range of variation in the number of cusps present on molar teeth. We are now concerned with the arrangement of these cusps. *Figure 43* illustrates four types of cusp pattern in the mandibular molars:

A. *The +4 pattern*, in which four cusps are separated by a cruciate groove system.

B. *The Y4 pattern*, where the cusps are separated by grooves obliquely set in the shape of a Y.

C. *The +5 pattern:* four cusps separated by a cruciate groove system, with the addition of a fifth distal cusp.

D. *The Y5 pattern*, in which the grooves are set in a Y-shaped arrangement because of contact between mesio-lingual and disto-buccal cusps. This is the primitive "Dryopithecus pattern" which is found in the mandibular molars of Dryopithecus ("the oak-ape"), fossil man, and in living anthropoid apes. In modern White populations three-quarters of the people show this pattern on their first mandibular molars, and only one-quarter on their second. The incidence is higher in Mongoloids.

9. *Tooth loss*

When examining skulls, it is of interest to determine whether any missing teeth were lost before or after death. *Figure 44* is a drawing of three mandibles showing tooth loss.

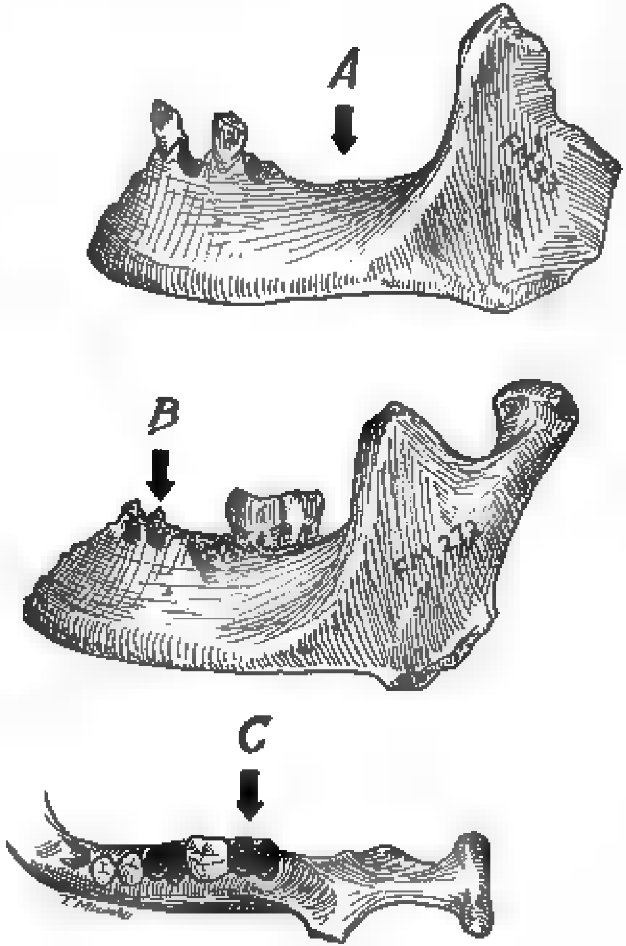

Figure 44

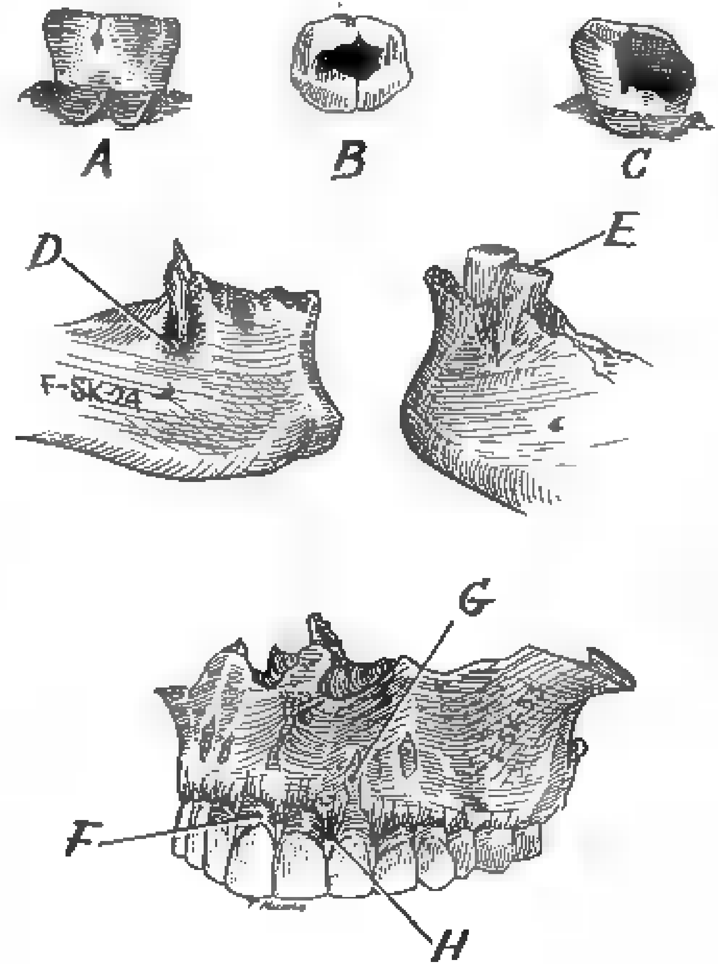

Figure 45

A illustrates premortem loss of the posterior mandibular teeth with closure and healing of the socket and loss of the supporting alveolar bone.

B shows pitted, irregular sockets, indicating disease of the dental supporting structure, thus providing a very loose attachment for the teeth in life.

C shows that in this mandible the sockets for the missing teeth are sharp and well defined, indicating postmortem loss.

10. *Dental Caries*

When noted in anthropological material, dental caries is described under the heading of type, location and extent. Caries develops either in existing pits and fissures on the tooth's surface or on the approximal surface where two adjacent teeth are in contact and where food may become impacted. *Figure 45* illustrates three carious molar teeth:

A has a small cavity in a fissure on its buccal surface.

B illustrates more extensive caries of the pit and fissure type occurring on the occlusal surface of a molar.

C shows extension of approximal caries destroying almost half of a molar crown.

11. *Infection*

This occurs when bacteria gain access to the tooth socket through caries, through pockets in the soft tissue around the neck of a tooth, or through a pulp canal exposed by excessive wear. *Figure 45D* is an example of this latter type in which infection, having localized around the root of the tooth, forms an apical abscess, which in life would have been a pocket of pus.

12. *Periodontal disease*

This is a destructive pathological process affecting the supporting soft and bony tissue of the tooth. *Figure 45E* is a drawing of part of the mandible of an Eskimo. Excessive attrition with exposure of the dentine is accompanied, as frequently is the case, by unhealthy, receding, alveolar margins. In the same figure is an illustration of the maxilla of an Indian with full dentition, marked attrition, and periodontal disease.

Note: F. Recession of soft tissue and bone, uncovering part of the cementum-coated area of the tooth.

G. Thinning of the alveolar bone with exposure of the roots.

H. The rolled, thickened condition of the alveolar margin, representing reaction to vigorous masticatory function and perhaps also to the inflammatory process.

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CHAPTER X

MEASUREMENT OF THE SKULL

Craniometry, or measurement of the skull, is done for two reasons:

1. To translate qualitative judgments into quantitative figures. Describing [redacted] skull as "long" is not so precise as stating "The length of this skull is 193 mm."
2. To demonstrate the relationship of two measurements to each other. The third measurement produced conveys more information than does either of the two figures from which it was derived. Such ratios [redacted] known as *indices*. One example is the Cranial Index which, by expressing the breadth of the skull [redacted] percentage of its length, describes the form of the skull in quantitative terms.

This book is an introduction, not [redacted] comprehensive guide, to craniometry. Definitive texts are listed in the bibliography.

Two of the instruments used in anthropometry are illustrated in *Figure 46*. These [redacted] sliding calipers and spreading calipers.

LANDMARKS FOR CRANIOMETRY

Certain points on the skull have been given Greek [redacted] for convenience of description because of their value as landmarks for cranial measurements. The more commonly used terms [redacted] defined here.

Glabella: Literally, the bald [redacted] between the eyebrows. The most prominent point on the frontal bone between the supraorbital ridges in the midline.

Bregma: The point at the junction of coronal and sagittal sutures.

Basion: The centre point on the external surface of the anterior border of the foramen magnum.

Maxillofrontale: The point at which the anterior lacrimal crest, prolonged upwards, meets the frontomaxillary suture.

Nasion: The point of intersection of the internasal and nasofrontal sutures.

Gnathion: The midpoint on the lower border of the symphysis menti.

Prosthion: The most anterior point on the alveolar process of the maxilla between the central incisor teeth.

By convention, the skull is described and measured when oriented in the *Frankfort Plane*. This position is achieved when the lowest point of the left inferior orbital margin is at the [redacted] horizontal level as the most lateral point of the roof of the external auditory meati.

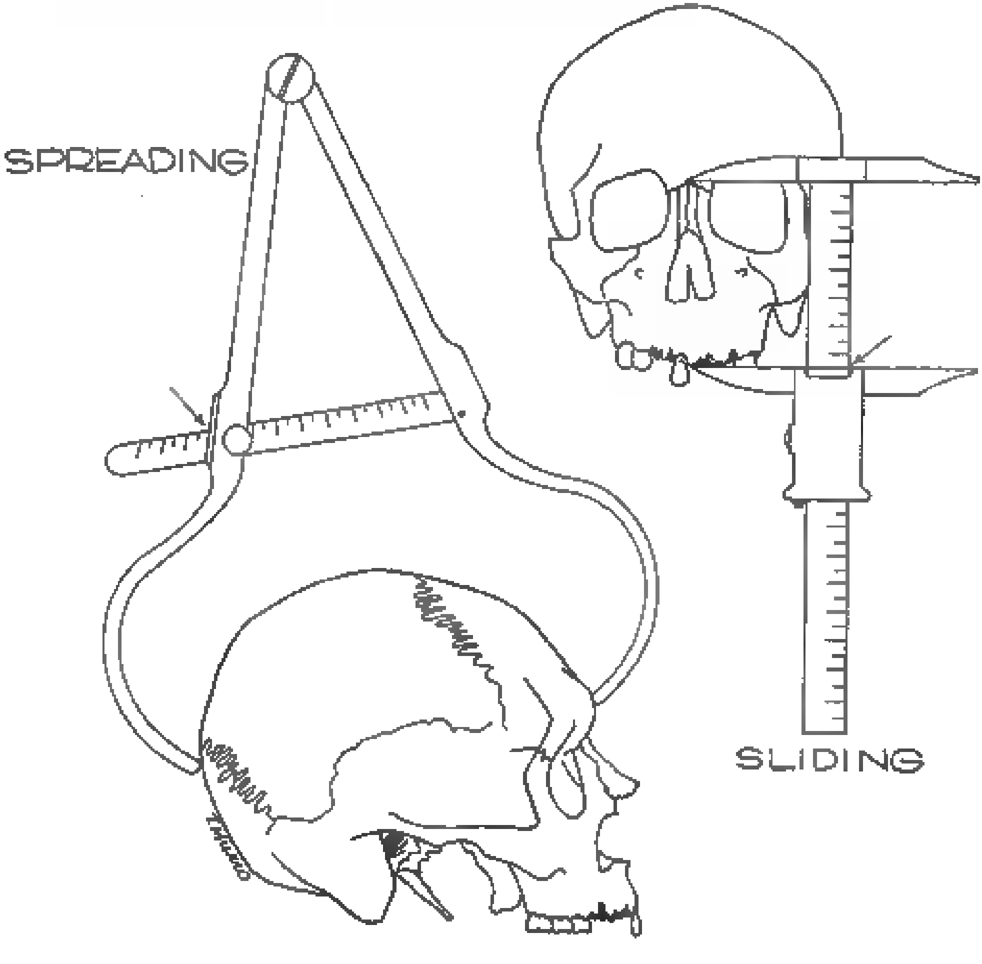

Figure 46

Quantitative Determinations on the Skull

The measurements of the skull described in this manual are as follows:

A. Maximum length
B. Maximum breadth
C. Basion-bregmatic height
D. Auricular height
E. Minimum frontal breadth
F. Total facial height
G. Upper facial height
H. Facial width
I. Nasal height
J. Nasal breadth
K. Orbital height
L. Orbital breadth
M. Length of palate (maxillo-alveolar)
N. Breadth of palate (maxillo-alveolar)
O. Length of mandible
P. Bicondylar width
Q. Height of the symphysis menti
R. Minimum breadth of ramus
S. Angle of mandible

From these measurements, nine informative indices may be derived:

1. Cranial Module
2. Cranial Index
3. Height-Length Index
4. Height-Breadth Index
5. Facial Index
6. Upper Facial Index
7. Nasal Index
8. Orbital Index
9. Palatine (Maxillo-Alveolar) Index

In the remaining part of this chapter, these measurements and their derived indices will be discussed in the above order. Measurements made with spreading calipers are labelled (SP), and those made with sliding calipers are labelled (SL).

The Skull as a Whole

The first three measurements listed, A, B, and C, are the preliminary attempts to determine size and proportions of the skull, indicating, as they do, length, breadth, and height.

A. *Maximum length* of the vault is determined by placing the fixed limb of the spreading calipers on the glabella and allowing the free limb to seek the most distant point in the sagittal plane on the occiput (SP).

B. *Maximum breadth* of the vault is found by moving the spreading calipers back and forth in the region above the supramastoid crest until maximum spread in a transverse direction has been reached (SP).

C. *Basion-bregmatic height*—with the skull lying on its left side facing the worker, the fixed limb of the spreading caliper is placed on the basion. The free limb is then placed on the bregma (SP).

From these measurements we may derive four useful indices:

1. *The Cranial Module* which provides a rough numerical value for the size of the skull. It is produced by adding all three measurements and dividing by 3: $\frac{A+B+C}{3}$

2. *The Cranial Index* (known as Cephalic Index when measured on the living subject) expresses the relationship of length to breadth in percentage.

$$\text{Cranial Index} = \frac{\text{B (breadth)}}{\text{A (length)}} \times 100$$

Obviously, the greater the breadth, the higher will be the index; the narrower the skull, the lower the index. By convention, values between 75.0 and 79.9 are considered median or *mesocranial*. Values below this are *dolichocranial* (narrow, or long headed); values above this are *brachycranial* (broad, or round headed).

3. *The Height-Length Index* expresses as a percentage the proportion of height to length of skull.

$$\text{Height-Length Index} = \frac{\text{C (height)}}{\text{A (length)}} \times 100$$

The greater the height of skull in relation to its length, the greater will be the value of this index. Average is considered to be 70 to 74.9 (Orthocranic). Figures below this indicate a low skull (Chamaecranic); figures above this indicate a high skull (Hypsicranic).

4. *The Height-Breadth Index* is an indication of the relationship of the height to the breadth of the skull expressed as a percentage.

$$\text{Height-Length Index} = \frac{\text{C (height)}}{\text{B (breadth)}} \times 100$$

The range of average is set at 92 to 97.9 (Metriocranic). Higher values denote a skull that is high in relation to its width (Tapeinocranic); lower values denote a skull that is low in relation to its width (Acrocranic).

D. *Auricular height* is a measure of the height of the skull vault above the level of the external auditory meati. The skull is held in the Frankfort Plane using a Craniostat, and the auricular height is read directly from a sliding scale. This measurement is illustrated in *Figure 47*.

E. *Minimum frontal breadth* is the minimum breadth between right and left temporal crests on the frontal bone (SP).

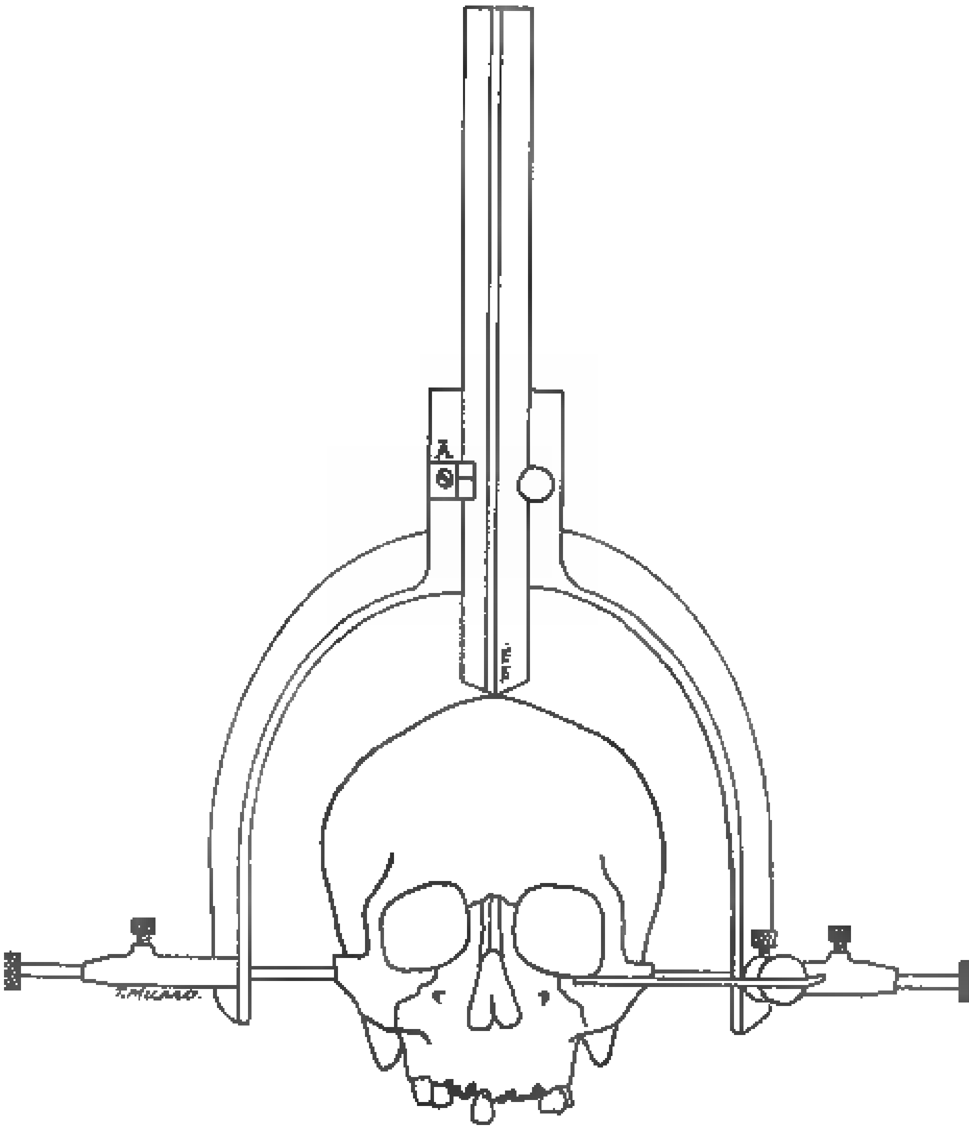

Figure 47

The Facial Region

There are three essential measurements required for determining the size of the face.

F. *Total facial height* is measured from nasion to gnathion, with teeth in normal occlusion. It thus gives a measure of height of complete face including jaws (SL).

G. *Upper facial height* is the height of face excluding teeth and mandible. It is measured by placing the fixed limb of sliding calipers [redacted] the nasion and the movable point on the prosthion (SL).

H. *Facial width* is measured as the bizygomatic diameter, which is the widest point between zygomatic arches in the horizontal plane (SP).

The relationship of these measurements to each other is expressed in two indices.

5. *Facial Index* $= \dfrac{\text{G (total facial height)}}{\text{I (facial width)}} \times 100$

It is evident that the greater the index, the narrower the face. The range 85 to 90 has been chosen [redacted] median (Mesoprosopic). Values below 85 denote broader faced (Euryprosopic); values above 90 denote narrower faced (Leptoprosopic).

6. *Upper Facial Index* $= \dfrac{\text{H (upper facial height)}}{\text{I (facial width)}} \times 100$

Here, the median is (50 Mesene) with narrow face values falling above (Leptene) and broad face values falling below this figure (Euryene).

The Nasal Region

The measurements required are—

I. *Nasal height*, which is measured from nasion to the mean of the lowest points of right and left nasal margins on each side of the nasal spine (SL).

J. *Nasal breadth*, which is the widest point of the anterior nasal aperture measured in a horizontal plane (SL).

7. The *Nasal Index*, which is derived from these two [redacted] urements, indicates the relationship of height to breadth of the anterior nasal aperture.

$$\textit{Nasal Index} = \frac{\text{K (nasal breadth)}}{\text{J (nasal height)}} \times 100$$

The average Nasal Index is set at 48 to 53 (Mesorrhine). Lower values indicate narrow nasal aperture (Leptorrhine). Higher values indicate wide nasal aperture (Chamaerrhine).

The Orbits

K. *Orbital height*, which is measured by [redacted] of sliding calipers, represents the maximum distance perpendicular to the plane of the orbit between upper and lower margins of the orbit, using the middle of the inferior border as a fixed point (SL).

L. *Orbital breadth* is the maximum width of the orbit from maxillofrontale to the middle of the lateral border of the orbit (SL).

8. *The Orbital Index* expresses the relationship of these two measurements.

$$\textit{Orbital Index} = \frac{\text{L (orbital height)}}{\text{M (orbital width)}} \times 100$$

Average is 83 to 88.9 (Mesoconch).
Figures lower than 82.9 denote wide orbits (Chamaeconch).
Figures higher than 89 denote narrow orbits (Hypsiconch).

The Palate (external measurements)

M. *Maxillo-alveolar* length is measured in the median plane from the prosthion to a line joining the posterior edges of the maxillary tuberosities (SL).

N. *Maxillo-alveolar breadth* is the maximum transverse diameter of the alveolar arch above the molar teeth (SL).

9. $$\textit{Maxillo-Alveolar Index} = \frac{\text{O (breadth of palate)}}{\text{M (length of palate)}} \times 100$$

Average is 110 to 115.

THE MANDIBLE

O. *Length of mandible* is measured by placing the condyles squarely against the vertical edge of [redacted] measuring board and applying a square to the tip of the chin. This distance is known [redacted] the condyle-symphysial length.

P. *Bicondylar width* is the distance between external surfaces of the mandibular condyles (SL).

Q. *Height of mandibular symphysis* is measured from the lowest point of the jaw in the median plane to the alveolar process between the mandibular medial incisors (SL).

R. *Minimum breadth of ramus* is the shortest distance in the horizontal plane between anterior and posterior borders of the left ramus (SL).

S. *Angle of the mandible* is the angle between mandibular body and the posterior edge of the ramus as measured with a goniometer.

SUMMARY OF CERTAIN INDICES

CRANIAL INDEX

Dolichocranial: less than 75 (long headed)
Mesocranial: 75.0 to 79.9
Brachycranial: greater than 80.0 (broad headed)

LENGTH-HEIGHT INDEX

Chamaecranic: less than 70.0 (a low skull)
Orthocranic: 70.0 to 74.9
Hypsicranic: greater than 75.0 (a high skull)

BREADTH-HEIGHT INDEX

Tapeinocranic: less than 92.0 (low in relation to width)
Metriocranic: 92.0 to 97.9
Acrocranic: 98.0 and above (high in relation [redacted] width)

FACIAL INDEX

Euryprosopic: less than 85.0 (broad faced)
Mesoprosopic: 85.0 to 89.9
Leptoprosopic: 90.0 and above (narrow faced)

UPPER FACIAL INDEX

Eurene: less than 50.0 (wide upper face)

Mesorene: 50.0 to 54.9
Leptorene: 55.0 and above (narrow upper face)

ORBITAL INDEX

Chamaeconchic: less than 83.0 (wide orbits)
Mesoconchic: 83.0 to 89.9
Hypsiconchic: 90.0 and above (narrow orbits)

NASAL INDEX

Leptorrhine: less than 47.0 (narrow nasal aperture)
Mesorrhine: 47.0 to 50.9
Chamaerrhine: 51.0 and above (wide nasal aperture)

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CHAPTER XI

QUALITATIVE OBSERVATION OF THE SKULL

Qualitative observations are those which are not usually expressed in numbers, although in many cases a quantitative comparison with standards is made. Because of the subjective element involved, this comparative type of measurement is poorly transmitted from one observer to another and so is limited in its value.

There are four types of qualitative observation that may be made:

1. *Measurement of degree*—This includes determination of size (e.g., mastoid process), amount of angulation (e.g., frontal slope), and prominence (e.g., strength of muscle markings). This type of measurement is commonly reported by the use of plus signs, the greater number of signs denoting increasing degree of the characteristic described. A common scale is as follows:

0	—absent
+	—trace or slight
++	—moderate
+++	—marked
++++	—extreme

2. *Description of shape*—Examples of this type of observation are shape of orbit and form of skull vault. Such terms [redacted] round, square, and pentagonal [redacted] used in grading.

3. *Description of form*—Observations of this sort answer such questions as "Do the supraorbital vessels and nerve run through a canal, [redacted] groove, or [redacted] notch?" or "Is the inion a ridge, a mound, or a point?"

4. *Description of arrangement*—Here, the observer states the relationship of structures to each other [redacted] in the direction of the transverse palatine suture or the arrangement of the bones at the pterion.

Vault Form

The shape of the skull as seen from above may bear [redacted] resemblance to [redacted] of [redacted] number of geometrical shapes:

Ellipsoid: An elongated oval, [redacted]
Ovoid: egg-shaped, or
Spheroid: round, or
Pentagonal: five-sided.
Rhomboidal: Oval with [redacted] little angularity at the sides.
Sphenoid: Wedge-shaped, with the angle of the wedge flattened in the frontal region.

Sagittal Crest

A midline crest in the sagittal plane giving a keel-like appear[redacted] to the skull vault.

Suture Patterns

There is considerable variation in the degree of complexity of the sutures which separate the adjacent bones of a skull. The complexity of a suture depends both on the number of convolutions per inch and upon the amplitude and tortuousness of each convolution. Racial differences exist in suture patterns.

Form of the Pterion

The pterion is the region of contact [redacted] the lateral side of the skull of Frontal, Parietal, Sphenoid, and Temporal bones. The "*H*" form exists when parietal and sphenoid bones are in contact with each other and separate the other two bones from each other. The "*X*" type of arrangement occurs when all four bones contact each other at a point. In the "*K*" type, the temporal and frontal bones [redacted] in contact with each other. Occasionally a fifth element is present at the pterion, an epipteric bone. The commonest arrangement in modern [redacted] is the "*H*" form.

Frontal Slope

The frontal slope, best seen in side view, varies from a straight almost vertical forehead to [redacted] acutely angulated one.

Brow Ridges

The supraorbital or brow ridges may be separated into right and left parts above each orbit; the two may be continuous across the midline, may consist of a single median bar, or may be V-shaped. The degree of brow ridge prominence should also be noted as it is a guide to determining the sex and racial type of the skull.

Bossing

Rounded prominences called *bosses* may be present on each side in the frontal and parietal regions. They may represent the site of the centre of ossification for the frontal and parietal bones. They are most marked in juvenile and female skulls.

Facial Build

The architecture of the face reflects size of facial bones, their degree of projection, and the strength of muscle markings. A general impression of facial appearance may be given by use of the terms "delicate," "average," or "rugged."

Projection of Zygoma

The prominence of the cheeks depends on the size of the zygoma and the degree to which it projects from the facial skeleton. This degree of projection is best [redacted] from below. It should be noted that [redacted] the zygomatic arch projects further laterally, a larger space exists for the temporalis (a muscle of mastication) to pass downward to the mandible. Prominence of the zygoma is characteristic of the mongoloid skull.

Prognathism

Facial prognathism is the term applied to skulls in which the whole facial region as well as the jaw projects forward. In these, the face is set [redacted] an obtuse angle to the horizontal plane of the skull. In straight-faced people, the facial axis is almost perpendicular to the horizontal plane.

Alveolar prognathism refers to an anterior projection of the alveolar processes of the mandible and maxilla. Negroid and Australoid skulls display both facial and alveolar prognathism. Facial prognathism is not usually found in Mongoloid or White skulls, but varying degrees of alveolar prognathism may be present.

Supraorbital Region

The supraorbital vessels and [redacted] may pass through a bony canal, a foramen, or a notch to reach their destination [redacted] the face. Like other foramina in the skull, supraorbital foramina may be multiple and may vary somewhat in relation to other bony landmarks.

Shape and Inclination of Orbit

As described in the previous chapter, the Orbital Index states the relationship between width and height of the orbit. The apparent shape of the orbital margin is described by comparison with geometrical forms: square, rectangular, round, elliptical, or rhomboid. The degree of inclination of the orbit is stated as the angle between the lower orbital margin and the horizontal plane.

Nasal Bones

The nasal bones are either rectangular, hour-glass shaped, or wedge shaped. The nasal profile may be straight, concave, convex, or concavo-convex.

Nasal Aperture

The anterior nasal aperture is either round, oval, rectangular, or piriform. The sharpness of its inferior margin and the prominence of the anterior nasal spine should be noted.

Shape of Palate

The size and proportions have already been studied quantitatively. The shape of the hard palate surrounded by the dental arch takes one of three geometrical forms—parabolic, hyperbolic, or elliptical.

Transverse Palatine Suture

The suture between the palatine process of the maxilla and the horizontal plate of the palatine bone may be straight, concave anteriorly, concave posteriorly, or irregular. The commonest form of the suture is concave anteriorly. There is an increased incidence of the straight type in Mongoloid skulls.

The Mastoid Process

The mastoid process of the temporal bone, to which attaches the sterno-mastoid muscle, varies considerably in size in different populations. It is larger in males than in females, and larger in adults than in children.

External Auditory Meatus

The porus or external opening of the external auditory meatus may be round, oval, or slit-like. The canal itself is either tubular or funnel-shaped. The floor of the canal is formed by the tympanic plate which varies in thickness.

Mandibular Fossa

The mandibular (glenoid) fossa, which accommodates the head of the mandible, is situated on the inferior surface of the temporal bone. Its depth is variable and seems to be related to genetic factors rather than to functional ones.

Occipital Region

The occipital curvature as seen in profile should be noted. The position of the apex may be high, medium, or low in relation to the line joining lambda to the posterior point on the foramen magnum. The external occipital protuberance may take the form of a peak, a ridge, a mound, or a combination of these.

Form of the Chin

The chin, formed by the anterior part of the mandible, may be square (bilateral), pointed (median), or a combination of the two (medio-bilateral).

Gonial Angle

The angle of the mandible may be curled inwards (inversion), flat, or flared outwards (eversion). Marked eversion of the gonial angle is typical of Eskimo mandibles.

Mental Foramen

The mental foramen transmits vessels and a nerve to the region of the chin. Usually it is single, points upwards and backwards, and lies at the vertical plane near the root of the second premolar tooth. Variations may occur in number, direction, and location.

Genial Tubercles

The genial tubercles, on the inner surface of the mandible at the junction of right and left halves, are two paired prominences for the attachment of muscles. Their arrangement and size are best recorded in a diagram.

SUMMARY

Vault of the Skull

Form
Sagittal Crest
Suture Pattern
Form of Pterion

FRONTAL REGION

Frontal Slope
Brow Ridges
Bossing

FACIAL REGION

Facial Build
Projection of Zygoma
Prognathism

ORBITS

Supraorbital Foramen
Infraorbital Foramen
Shape of Orbit
Inclination of Orbit

NASAL REGION

Shape of Nasal Bones
Nasal Bridge Profile
Shape of Aperture
Inferior Margin
Anterior Nasal Spine

PALATE

Shape of Palate
Transverse Palatine Suture

TEMPORAL BONE

Size of Mastoid Process
Form of External Auditory Meatus
Thickness of Tympanic Plate
Depth of Glenoid Fossa

OCCIPITAL REGION

Occipital Curvature
Position of Apex
Form of External Occipital Protuberance

MANDIBLE

Chin Form
Gonial Angle
Mental Foramen number
direction
position
Genial Tubercles

CHAPTER XII

CRANIAL ANOMALIES

The preceding chapter discussed variations of the skull that can be expressed in differences of degree, shape, form, or arrangement. These are *continuous* traits in that they are present in all skulls, but with varying amounts of expression.

Cranial anomalies may be referred to [redacted] *discontinuous* or *discrete* traits because they are either present or absent in any [redacted] skull. The possibility that they are genetically determined makes them particularly valuable in the analysis of [redacted] skeletal population.

Figure 48 shows some of these anomalies:

A. *Accessory* or *Wormian* bones in the region of the bregma.

B. The commonest site for Wormian bones, in the lambdoid suture.

C. The *metopic suture*, a suture between the right and left parts of the frontal bone which may persist into adult life.

D. *Precondylar tubercles*, small bony protuberances sometimes found in the region of the anterior margin of the foramen magnum.

E. The lateral pterygoid plate is connected to the spine of the sphenoid, forming a *pterygo-spinous foramen*.

F. *Os japonicum*. The zygoma is divided into two bones by [redacted] suture.

G. *Paramastoid tubercle*, a downgrowth from the jugular process just medial to the mastoid process.

H. A *carotico-clinoid foramen*, in which the anterior clinoid process is connected to the body of the sphenoid by [redacted] bridge of bone which forms a foramen for the internal carotic artery.

I. A defect or *dehiscence in the tympanic plate*, an [redacted] of ossification.

J. *Two mental foramina* found on [redacted] side of the mandible.

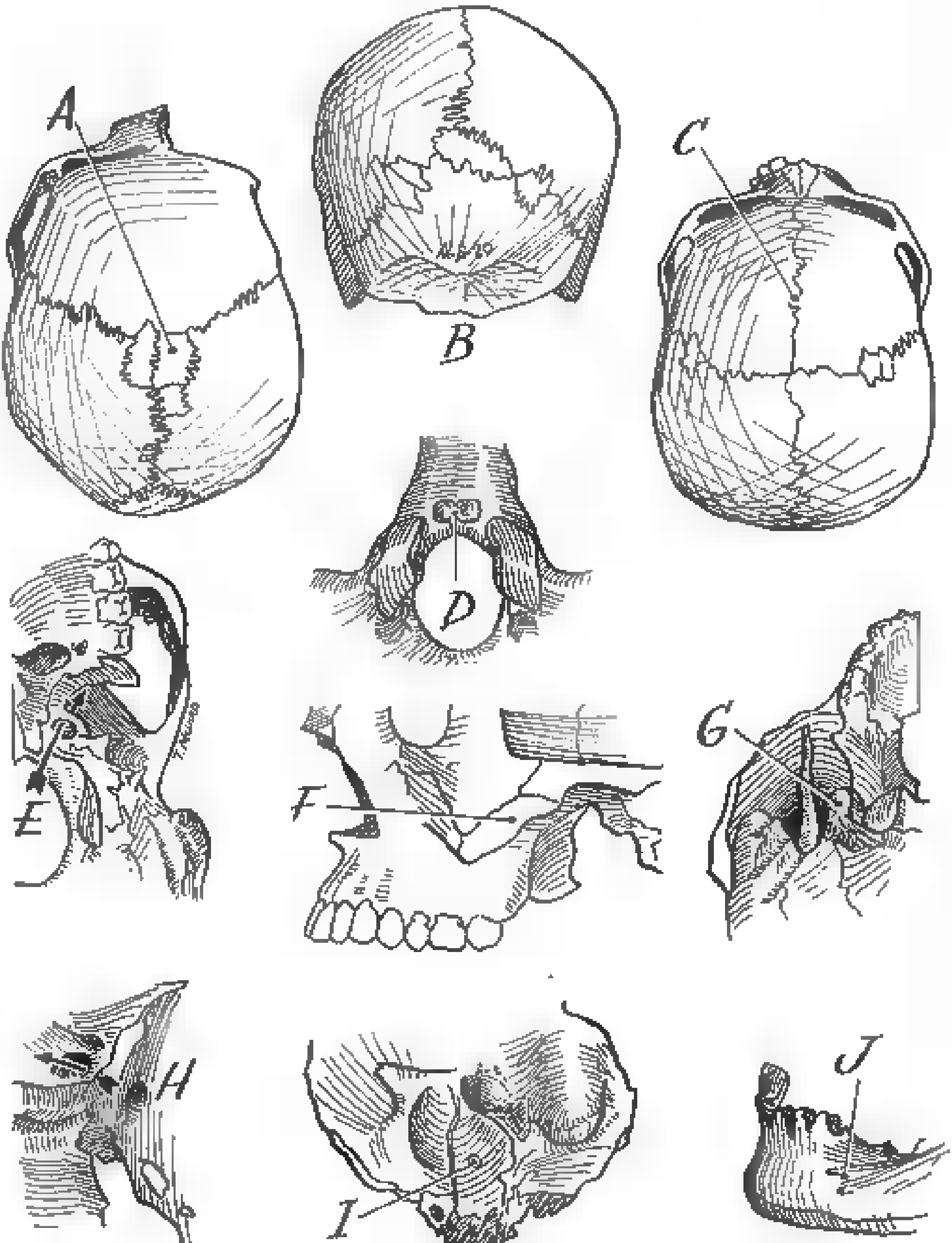

Figure 48

Other cranial anomalies, not illustrated here, include:

torus palatinus, a median bony elevation [redacted] the palate.

torus mandibularis, a mound of bone on the inner surface of the body of the mandible.

os inca, a large triangular accessory bone behind the lambdoid suture, representing a separate upper part of the occipital bone.

epipteric bones, accessory bones found at the pterion.

Vesalian foramen, an additional foramen between the foramen ovale and the foramen rotundum.

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CHAPTER XIII

THE INFRACRANIAL SKELETON

As with the skull, observations made on the infracranial skeleton are both quantitative and qualitative.

Measurement of Long Bones

To determine length of bones a *measuring board*, calibrated in millimetres, is used; it has a vertical rim along one end and one side. To measure the length of a long bone, its head is placed against the vertical end part of the board; [redacted] squared block is applied to the opposite end; then the bone is moved carefully in horizontal and vertical planes until maximum length has been determined.

Diameter of long bones may be determined by a sliding caliper. The mid-point of the shaft is determined and marked, and here the maximum and minimum diameters are measured.

A goniometer, which consists of a protractor with [redacted] movable arm, is employed to determine skeletal angles.

More explicit directions for the various measurements of the infracranial skeleton may be sought in one of the standard anthropometric textbooks.

Length and diameter are routinely reported for humerus, radius, ulna, femur, tibia, and fibula. The measurements found are used in estimation of stature, build, and limb proportion.

Flattening of the shafts of femur and tibia may be observed in the skeletons of certain populations. Sagittal and transverse diameters of the femur are measured by [redacted] of sliding calipers applied to the shaft just below the lesser trochanter. The relationship between the two measurements is shown in an index:

$$\frac{\text{Sagittal—diameter}}{\text{Transverse diameter}} \times 100$$

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Values below 80 indicate flattening of the shaft or *platymeria*. The same condition when found in the tibia is termed *platycnemia*. Measurements are taken at the level of the nutrient foramen, and the Index of Platycnemia is

$$\frac{\text{Transverse diameter}}{\text{Antero-posterior diameter}} \times 100$$

Sliding calipers are used to measure the ***maximum diameter*** of the head of humerus, femur, and radius. This information is of value in the estimation of sex of the individual.

Measurement of Angularity

The shafts of long bones may exhibit varying degrees of bowing, angularity, and torsion.

The *condylo-diaphyseal angle* is that between the distal end and the shaft of the humerus. A large angle is said to be characteristic of North American Indians.

Femora show much variation in the angle of neck to shaft, anterior bowing of the shaft, and torsion of the shaft. The latter is seen most clearly by examining the bone end-on, sighting along its shaft, and noting the angle made between proximal and distal ends.

Anomalies of the Infracranial Skeleton

Some anomalies of the infracranial skeleton [redacted] shown in *Figure 49*:

A. *Septal aperture* at the distal end of the humerus. The olecranon and coronoid fossae communicate through a foramen.

B. *Failure of fusion* of the posterior arch of the atlas vertebra.

C. A *foramen in the sternum*, resulting from [redacted] error of ossification.

D. Partial fusion of the fifth lumbar vertebra to the sacrum.

E. A prominent gluteal ridge on the femur, forming [redacted] *third trochanter*.

F. A *fossa of Allen*, an impression on the neck of the femur.

G. A double foramen transversarium in the seventh cervical vertebra.

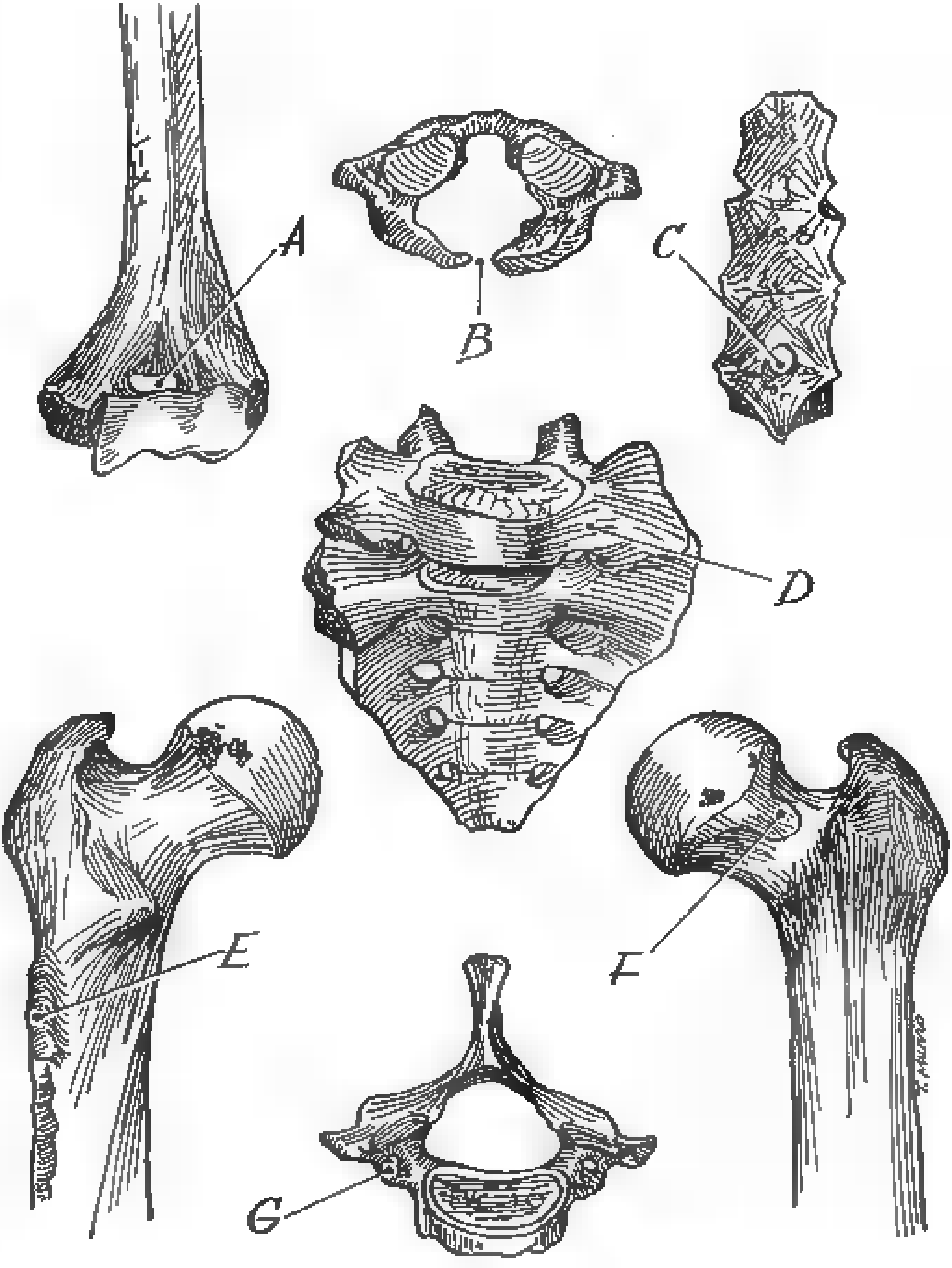

Figure 49

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CHAPTER XIV

RECONSTRUCTING THE INDIVIDUAL

Reconstruction of the individual is an attempt by the investigator to clothe the bare bones of the skeleton and produce a picture of the person as he was in life. This reconstruction is done by estimating the stature, proportion, build, posture, age, sex, physical stock, state of health, and nutrition of the individual.

Background data have been accumulated over the years from the study of skeletons whose appearance in life was known. It is upon this fund of knowledge, statistically analysed, that our "educated guesses" are based.

STATURE

The estimation of living stature from the skeleton is done by means of regression equations applied to the measurements of the long bones. Many such systems, based upon studies of series of skeletons of known stature, have been reported.

Results of the most recent work by Trotter and Gleser (1958) are shown in *Figure 50*, which is Table 12 from their paper. It may be noted that variation occurs between stature estimations for different races. The equation used will depend on which parts of the skeleton are available for study. As shown in the table, lower limb measurements give more accurate results than those from upper limbs. If all the skeleton is available, the most reliable estimation is calculated from femur and fibula. Averaging results from a number of equations is less accurate than that derived from one equation.

BUILD

The general build of the individual may be conjectured from the ruggedness of muscle markings, the diameter of the long bones, and the length of the clavicle.

Reconstruction of the head region is done by using a knowledge of the thickness of the soft tissues overlying the various areas of the skull.

PROPORTION

The proportion of the various regions of the body to each other varies between individuals and particularly between racial groups.

Indices have been derived to put these differences in quantitative terms.

1. The relationship of upper limb length to lower limb length is expressed as:

$$\frac{\text{Length of humerus and radius}}{\text{Length of tibia and fibula}} \times 100 .$$

   A low index indicates long legs in proportion to arms. This state exists typically in Australoids and in Negroids.

2. The relationship of length of upper arm to forearm is expressed as:

$$\frac{\text{Length of radius}}{\text{Length of humerus}} \times 100$$

   A high index indicates [redacted] proportionately long forearm.

3. The relationship of length of upper leg to length of lower leg is expressed in the ratio:

$$\frac{\text{Length of tibia}}{\text{Length of femur}} \times 100$$

   Here, a high index represents [redacted] proportionately short femur. As [redacted] general rule, White and Mongoloid indices are below 83, while Negroid and Australoid indices are greater than 83.

[redacted]

Estimation of living posture from the disarticulated skeleton is extremely difficult unless obvious pathological changes have occurred.

Curvature of the spine in the lower back may be estimated by measurement of the anterior and posterior heights of the lumbar vertebral bodies by means of sliding calipers. From these two measurements a ratio is expressed:

$$\textit{Lumbar Index} = \frac{\text{Posterior height of vertebra}}{\text{Anterior height of vertebra}} \times 100$$

This index gives a quantitative value to the profile shape of the vertebral body. Summation of anterior and posterior heights for the five lumbar vertebral bodies is used in calculation of the Lumbar Vertebral Index:

$$\frac{\text{Sum of posterior heights}}{\text{Sum of anterior heights}} \times 100$$

As will be noted, *if the index is one*, the sum of anterior heights equals that of posterior heights, and the back is straight. *If the index is greater than one*, the posterior heights exceed the anterior, and there will be a posterior convexity of the lumbar region. *If the index is less than one*, anterior heights are greater than posterior, and the lumbar region will show a posterior concavity.

The normal lumbar curvature in modern White races is similar to the latter, with a Lumbar Index of less than one. In many North American Indians, the Lumbar Index is close to one, suggesting a straighter lower back.

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WHITE

1.31 (Fem + Fib) + 63.05	±3.62	1.82 (Hum + Rad) + 67.97	±4.31
1.26 (Fem + Tib) + 67.09	±3.74	1.78 (Hum + Ulna) + 66.98	±4.37
2.60 Fib + 75.50	±3.86	2.89 Hum + 78.10	±4.57
2.32 Fem + 65.53	±3.94	3.79 Rad + 79.42	±4.66
2.42 Tib + 81.93	±4.00	3.76 Ulna + 75.55	±4.72

NEGRO

1.20 (Fem + Fib) + 67.77	±3.63	1.66 (Hum + Rad) + 73.08	±4.18
1.15 (Fem + Tib) + 71.75	±3.68	1.65 (Hum + Ulna) + 70.67	±4.23
2.10 Fem + 72.22	±3.91	2.88 Hum + 75.48	±4.23
2.19 Tib + 85.36	±3.96	3.32 Rad + 85.43	±4.57
2.34 Fib + 80.07	±4.02	3.20 Ulna + 82.77	±4.74

MONGOLOID

1.22 (Fem + Fib) + 70.24	±3.18	1.68 (Hum + Ulna) + 71.18	±4.14
1.22 (Fem + Tib) + 70.37	±3.24	1.67 (Hum + Rad) + 74.83	±4.16
2.40 Fib + 80.56	±3.24	2.68 Hum + 83.19	±4.25
2.39 Tib + 81.45	±3.27	3.54 Rad + 82.00	±4.60
2.15 Fem + 72.57	±3.80	3.48 Ulna + 77.45	±4.66

Figure 50

CHAPTER XV

AGE DETERMINATION

DETERMINING THE AGE OF THE SKELETON

A. The Long Bones

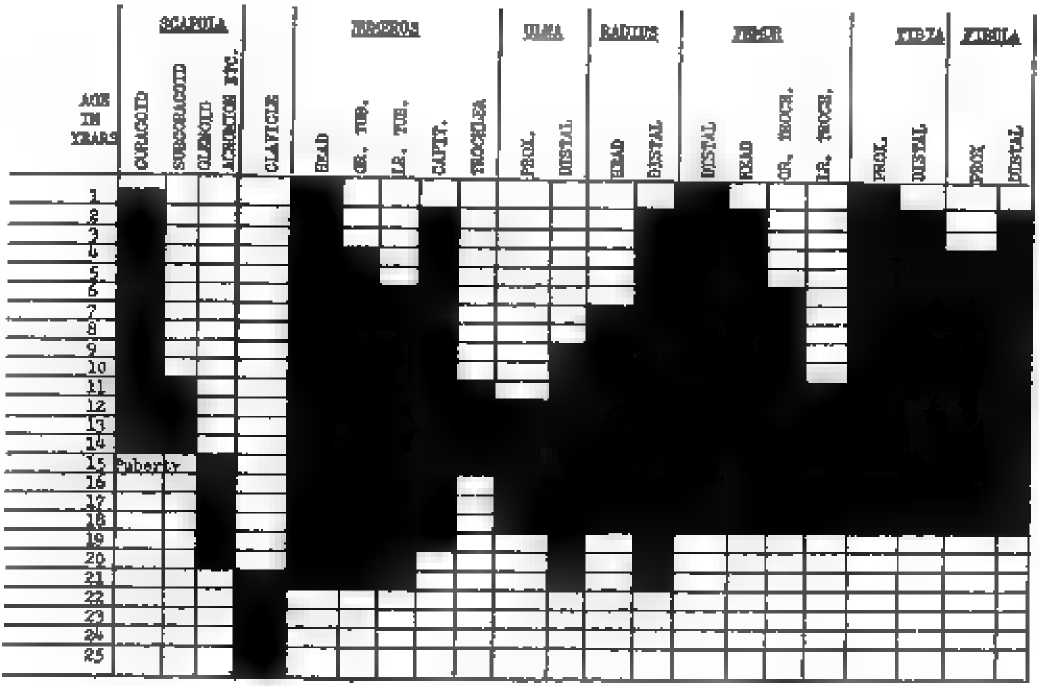
During prenatal life, the skeleton of long bones (except for the clavicle) is laid down in the form of [redacted] mould or pattern composed of cartilage. Hence, each typical long bone has a cartilaginous precursor, which eventually becomes ossified or converted into bone. Ossification occurs in the following manner: [redacted] *primary centre* of ossification appears in the centre of the shaft, and from this point ossification continues until the cartilaginous shaft is converted to bone. The part of the bone that develops from a primary centre is known as the *diaphysis*. Later, one or more *secondary centres* develop at proximal and distal ends. From them, ossification spreads until the two ends have been converted into bone. These [redacted] developing from secondary centres are termed *epiphyses.*

The area between epiphysis and diaphysis remains cartilaginous for some time because it is at this zone that growth in length of the bone occurs. When growth is complete, the zone of cartilage is obliterated, and the shaft becomes united to the bony caps at each end.

This method of development provides a series of events, the timing of which may guide us in estimating the age of [redacted] individual. These events are as follows:

1. The appearance of primary centres (before birth).
2. The appearance of secondary centres (most appear before puberty).
3. The fusion of epiphysis and diaphysis (age 12 to 25).

The age of appearance and fusion of the various secondary centres is shown graphically in *Figure 51*. Note that the upper limit of each bar marks the time of appearance of the centre, while the lower limit indicates the age of its fusion to the shaft.


SCAPULA
ULNA
RADIUS
TIBIA
FIBULA
AGE IN YEARS
CORACOID
SUBCORACOID
GLENOID
ACROMION ETC.
CLAVICLE
HEAD
GR. TUB.
LE. TUB.
CAPIT.
TROCHLEA
PROX.
DISTAL
HEAD
DISTAL
DISTAL
HEAD
GR. TROCH.
LE. TROCH.
PROX.
DISTAL
PROX
DISTAL
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Puberty
16
17
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23
24
25

Figure 51

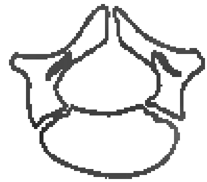
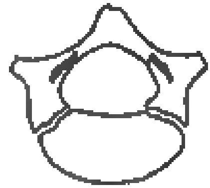
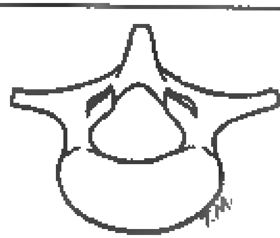
1 NEWBORN	3 PRIMARY CENTRES: BODY AND TWO NEURAL ARCH HALVES	
2 AGE 2	ARCH BEGINS TO FUSE AT BIRTH FROM LUMBAR TO CERVICAL REGION	
3 AGE 7	ARCH FUSES TO BODY FROM CERVICAL TO LUMBAR REGION	
4 PUBERTY	SECONDARY CENTRES FOR TIP OF SPINE, TRANSVERSE PROCESS ON UPPER & LOWER SURFACE OF BODY	
5 AGE 25	ALL CENTRES FUSE	

Figure 52

It should be realized that we are dealing with generalizations based on average growth in White males. There is a considerable range of variation between individuals, between the sexes, and between those of different populations. A number of generalizations may be made:

1. At birth, the following *secondary* centres are present:
   - Head of humerus
   - Distal end of femur
   - Proximal end of tibia
2. Centres that appear early fuse late.
3. Centres at the wrist appear before centres for the elbow.
4. Epiphyses at hip, ankle, and elbow fuse between age 14 to 18 years. Their fusion is complete in all individuals by age 20.
5. Epiphyses at the knee, wrist, and shoulder fuse between age 17 to 20 years. Their fusion is complete in all individuals by age 23.
6. The longest growth periods in the limbs occur at shoulder, wrist, and knee.

B. Vertebrae

The ossification plan for the vertebrae is somewhat more complicated. Three primary centres account for the ossification of the body and neural arch, while secondary centres appear later for the various processes and for the plate-like upper and lower surfaces of the bodies.

The sequence of changes is illustrated in *Figure 52*.

In the sacrum, the body and neural arches have united before puberty, secondary centres appear about age 18, and the sacral vertebrae fuse with each other in ascending order. Fusion of the lower four bodies is complete by age 23, but S1 and S2 may remain unfused until age 32.

C. Carpus

The carpal bones are cartilaginous at birth. Ossification occurs in sequence, which is approximately as follows:

Bone	*Age of Appearance in Years*
Capitate	One
Hamate	Two
Triquetrum	Three
Lunate	Four
Scaphoid	Five
Trapezoid	Six
Trapezium	Seven
Pisiform	Twelve

D. Tarsus

The sequence of ossification of the tarsal bones is approximately [redacted] follows:

Bone	*Time of Appearance of Primary Centre*
Talus, cuboid, body of calcaneus	—Present at birth
Lateral cuneiform	—During first year
Medial cuneiform	—End of second year
Middle cuneiform and navicular	—During third year
Posterior part of calcaneus	—Tenth year

Union of the body to the posterior part of the calcaneus occurs soon after puberty.

E. Sternum

The sternum, as previously described, consists of six elements: manubrium, xiphoid process, and four sternebrae. The approximate age of fusion of each of the adjacent elements is stated here in tabular form:

Junction Between	*Age of Fusion*
Manubrium and first sternebra	—Old age
First and second sternebrae	—Third decade. Complete by age 17 to 30.
Second and third sternebrae	—Puberty. Complete by age 17 to 25.
Third and fourth sternebrae	—Childhood
Fourth sternebra and Xiphoid	—Middle age

F. Patella

The centre of ossification for the patella appears between the ages of three and five years. Ossification is complete at puberty.

G. Pelvis

The innominate bone is formed by the fusion of three separate bones: ilium, ischium, and pubis, each of which forms its own centre of ossification. The three bones meet at a Y-shaped junction within the acetabulum. Union here is complete by the age of seventeen. Additional centres [redacted] present for ossification of the iliac crest and for certain other processes. These appear at puberty and fuse during the early twenties, fusion being complete in all individuals by age 23.

H. Fontanelle Closure

The bones of the vault of the skull develop in membrane rather than in cartilage. Their definitive form is more or less square, while ossification fans out in [redacted] circular [redacted] from their centre. At birth, ossification has not yet reached the corners of the bone, thus leaving gaps called fontanelles at the angular [redacted] of unossified membrane.

Figure 53 is a drawing of the skull of [redacted] newborn infant. Note the following:

A. A diamond-shaped *anterior fontanelle* at the junction of coronal and sagittal sutures. This *bregmatic* fontanelle is closed by the age of two years.

B. A triangular *posterior fontanelle* is present [redacted] the lambda where sagittal and lambdoidal sutures intersect. It is closed by six months of age.

C and D. Two tiny fontanelles at the lateral angles of the parietal bone, the region of asterion and pterion. These close within the first few weeks of postnatal life.

Notice also that the frontal bone during infancy consists of a right and left half, separated by [redacted] suture which is normally obliterated by the age of six years. When it persists into adult life, it is known [redacted] the *metopic suture*. There is almost always a vestige of it visible just above the nasion.

I. Suture Closure

The skull is formed by the union of a large number of bones, each developing from its own centre or centres of ossification. As age increases, these units gradually fuse with each other, their intervening sutures becoming progressively obliterated.

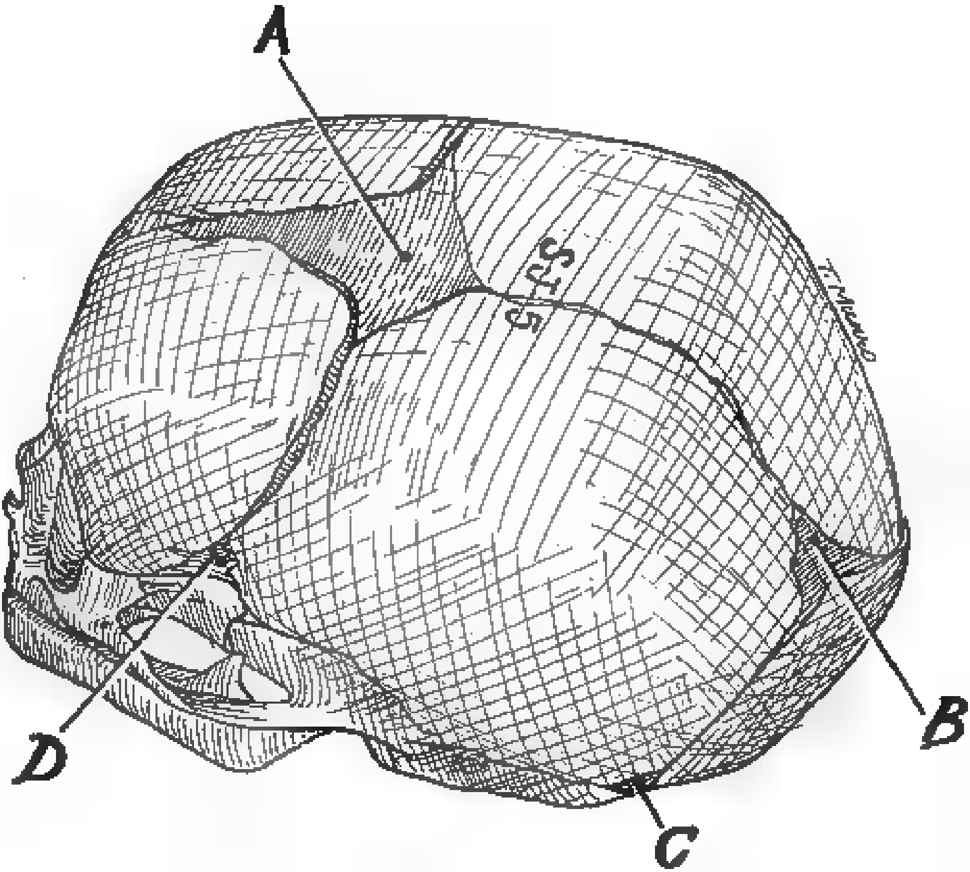


Figure 53

CRANIAL SUTURE CLOSURE

	METOPIC	SAG	CORONAL	LAMBDOID	SPH-TEMP.	SPH-[redacted]AL	SPH-FRONTAL	MASTO-OCCIP	SQU-[redacted]
Child	6 years								
Young Adult (21-35)									
Middle Aged (36-55			35	45					
Old Adult (56-75)					70	65	65		
Very old (75+)								80	80+

Figure 54

The use of suture closure [redacted] [redacted] indicator for age determination has been investigated by many workers. Sutures have been divided into "activity areas," and times for beginning and completion of closure have been reported for each. However, recent investigators have been unanimous in stating that suture closure is an unreliable method for age determination.

Figure 54 is a bar graph illustrating the sequence of suture closure in relation to age. In general terms, the older the individual the more sutures are closed. By combining the degree of closure of all sutures, the information is of some value in supporting estimations based on other criteria.

J. Spheno-Occipital Synchondrosis

The junction of sphenoid and occipital bones [redacted] the base of the skull is a primary cartilaginous joint. The space disappears, and the two bones fuse together completely by the age of 22 in all individuals, but fusion commonly occurs before age 17.

K. Eruption of the Dentition

The state of eruption of the teeth may be used as a guide to age determination in the young skull. The primary, milk, or deciduous dentition begins to erupt at about seven months of age and is complete by the age of two years. The secondary or permanent dentition begins to erupt at age six and is complete, except for the third molar, by the age of twelve.

The accompanying table of times of eruption may serve [redacted] a guide, bearing in mind the following points:

1. There is a normal range of times for individual tooth eruptions, one set of average determinations being given here.
2. The order of eruption given here is the usual but by no means the only pattern that may be observed.
3. Eruption time in females is somewhat earlier than in males.
4. In the permanent dentition, mandibular teeth usually precede maxillary teeth in eruption.
5. The pattern given is for eruption through the soft tissue of the gum, whereas in the skeleton we observe eruption through bone which precedes the former by a variable amount of time.

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TIMES OF ERUPTION

1. Primary Dentition

Age in Months	*Tooth*
7	Lower central incisors
9	Upper central and lateral incisors
11	Lower lateral incisors
14	1st molars
17	Canines
24	2nd molars

2. Permanent Dentition

Age in Years	*Tooth*
6	1st molars
7	Central incisors
[redacted]	Lateral incisors
9	1st premolars
10	2nd premolars
11	Canines
12	2nd molars
17–25	3rd molars

L. Appearance of the Symphysis Pubis

The symphysis pubis is the contact area, anteriorly, between right and left innominate bones. Its surface undergoes [redacted] series of changes throughout life. These changes form the most reliable indicator for age determination from the eighteenth to the fiftieth year of life.

Todd divided the changes that occur into ten stages, based on appearance of the contact surface and the condition of its margins. A simplified summary of these age stages is [redacted] follows:

Stage	*Age*	*Appearance*
1.	18–19	The surface is scored by rugged horizontal ridges separated by well-marked grooves. There is no definition of the margins of symphysis.
2.	20–21	Grooves [redacted] filling in dorsally, and the dorsal margin is beginning to develop.

3. 22–24 Fusing nodules of bone are obliterating the ridge system. The dorsal margin is more defined, and the surface is becoming bevelled ventrally.
4. 25–26 The dorsal margin is completely defined, and the inferior margin is beginning.
5. 27–30 The inferior margin is clearly defined, and margins are beginning ventrally and superiorly.
6. 30–35 The surface appears granular. The ventral margin is complete.
7. 35–39 Bony outgrowths into the tendons and ligaments begin.
8. 39–44 The surface is smooth and has [redacted] oval outline.
9. 45–50 A rim is forming around the margins of the symphysis. The lipping on the dorsal margin is uniform, and that on the ventral margin is irregular.
10. Over 50 The surface becomes pitted, and the ventral border begins [redacted] break down.

McKern and Stewart (1957) have developed [redacted] modification of this method which is very useful, particularly in the lower age groups. They have divided symphyseal changes into three components, each of which is scored separately. A set of plastic models is available for [redacted] with this system.

M. Other Techniques

Certain other changes in the skeleton may be related to the ageing process:

1. Alteration in the structure of cancellous bone in such regions as the proximal ends of the humerus and the femur.

2. Changes in the vascular pattern of the scapula as [redacted] when this bone is transilluminated.

3. Changes in the appearance of the teeth as seen in microscopic sections.

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CHAPTER XVI

SEX DETERMINATION

DETERMINATION OF SEX FROM THE SKELETON

A. The Appendicular Skeleton

As [redacted] general rule, the male skeleton reflects the masculine attributes of being taller, heavier, and more rugged than its female counterpart. Thus, as expected, we find individual bones of the male relatively longer and thicker, and with more marked muscular processes and ridges.

Joint surfaces in the male are also larger than in the female. For example, the diameter of the head of the femur is both relatively and absolutely greater in the male. Measurements may be made and compared with three ranges: male, female, and an intermediate doubtful zone.

B. The Skull

Sex differences in the skull are based upon the generalization that the female skull is smaller, less rugged, and more infantile in appearance than that of the male. Listed below [redacted] six points of differentiation:

1. *Skull size*. The male skull is notably larger than that of the female.
2. *Skull form*. Female skulls, because of the persistence of the frontal and parietal bossing of childhood, appear more rectangular than oval in outline, [redacted] [redacted] from above.
3. *Brow ridges* in the male are heavier than in the female, whose superior orbital margins [redacted] usually sharp and delicate.
4. *Mastoid processes* are larger in the male.
5. *Muscle markings*, as elsewhere on the skeleton, are more rugged in the male. These [redacted] particularly notable in the occipital region and at the temporal lines.

6. *Zygomatic bones* are more prominent in the male, because of the relative size of bone throughout all the skeleton and also because of the lateral projection of the male zygomatic arch which allows more space for the thicker temporalis muscle.

Among the difficulties encountered in applying these observations is the fact that many of them [redacted] points of racial difference as well as of sex difference. It is necessary, therefore, to set up standards for the particular population being studied, to record the observations on each of the determined points, and to give an opinion based on consideration of the total of all observations.

C. The Pelvis

Skeletal sex differences are most marked in the pelvis. The following points [redacted] illustrated in *Figure 55.*

1. *Muscle markings.* As in the rest of the skeleton, the male pelvis shows heavier markings for muscle attachment, which give it [redacted] more rugged appearance than that of the female. This includes the strong ridge on the ischiopubic ramus to which the base of the penis attaches.
2. *Capacity of the pelvic basin.* The female pelvic cavity is shorter, more spacious, and less funnel-shaped than that of the male. The female pelvis is [redacted] short segment of [redacted] long cone; the male pelvis is [redacted] long segment of [redacted] short cone.
3. *The subpubic angle.* The angle between the pubic rami in the male is more acute than in the female. As [redacted] rough rule, the male angle is that of the separated index and middle fingers, while the female angle is that of the separated thumb and index fingers.
4. *Pelvic shape.* Note that the pelvic inlet of the female is oval, while that of the male is heart-shaped owing to encroachment by the prominence of the sacrum. The pelvic outlet of the male is made smaller by internal projection of the ischial spines and the sacrum. In the female, the body of the sacrum is straighter than in the male.
5. *The sacrum.* Note the relative proportions of body of sacrum to the alae. In the male, the width of the sacral body is greater than that of each ala; in the female, width of the first sacral body is equal to that of each ala.

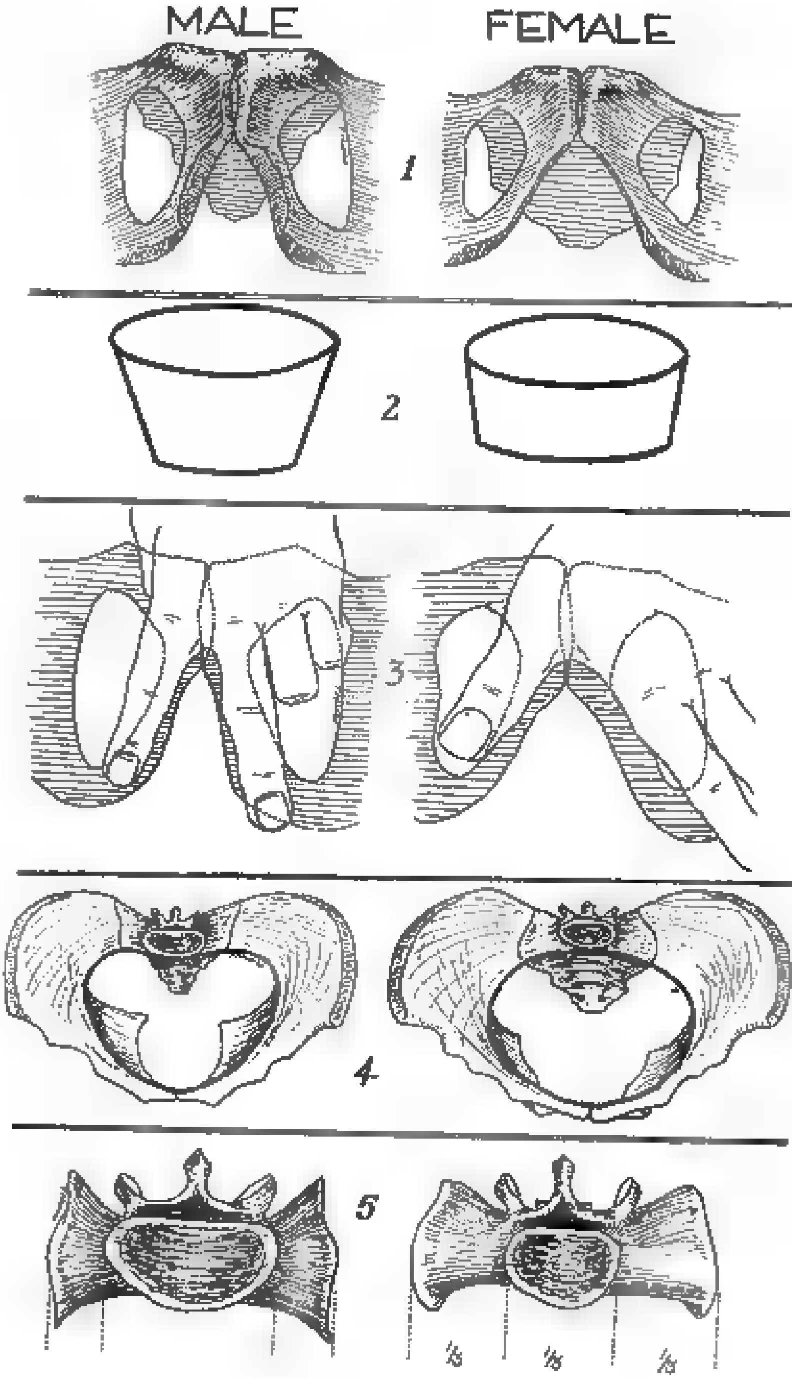

Figure 55

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CHAPTER XVII

PALAEOPATHOLOGY

Palaeopathology is the study of disease in prehistoric animals and man. It is both informative and difficult: informative because of the light it throws on the history of disease, and difficult because of the limitations of the available material.

Palaeopathology provides data for the study of the disease process, allowing us to examine the relationship of geographical and environmental factors to the occurrence of certain illnesses. It allows [redacted] to view disease against [redacted] much larger time scale than that provided by the written record. Anthropologically speaking, [redacted] may observe and speculate upon the influence of disease on culture, and conversely upon the structure of cultures which appear to be prone to certain diseases. More than this, the recognition of diseases similar to our own in ancient peoples provides a sympathetic link across the centuries and perhaps prepares us to understand better the total culture under scrutiny.

The study of palaeopathology is rendered difficult by the absence of signs and symptoms upon which [redacted] great part of medical diagnosis is based. As the material evidence is almost exclusively that of the skeleton, [redacted] limited to [redacted] study of diseases that affect bone.

In dealing with the skeletal material from a burial site, then, it will be necessary to examine each bone for any deviation from what we have come to appreciate [redacted] the normal. We then must attempt to classify the abnormality. A simple classification of acquired pathological change in bone [redacted] as follows:

1. Injuries [redacted] trauma
2. Infections
3. Tumours
4. Deficiency disease
5. Degenerations

1. INJURIES may be detected on the skeleton, sometimes offering evidence as to the cause of death of the individual. Indian burials [redacted] sometimes discovered with projectile points still embedded in [redacted] part of the skeleton. Mutilations and dismemberment may be encountered. Fractures [redacted] common, frequently showing signs of healing and sometimes evidence of secondary infection. Illustrated in *Figure 56* are examples of fractures:

A. *Callus* is an irregular swelling, here shown [redacted] the shaft of the fibula, which acts as a temporary splint uniting the two fragments. At first it is very marked, but [redacted] the bone heals it disappears, completely melting away.

B. *Disruption of the normal axis of the bone*. The two fragments of a fractured bone may grow together at an angle to each other, rotated one upon the other, or with ends not in line and overriding, producing [redacted] shortening of the limb as shown in this right femur.

C. *Deformity* may result from fractures, as it has here in this crush injury of a lumbar vertebral body, which is now wedge-shaped.

D. A well-healed but poorly aligned fracture of the clavicle, which shows angulation at the site of the break.

Injuries which interfere with the blood supply to bones may also result in deformities [redacted] in the skeleton. The head of the femur and the navicular bone [redacted] two common sites where this may occur.

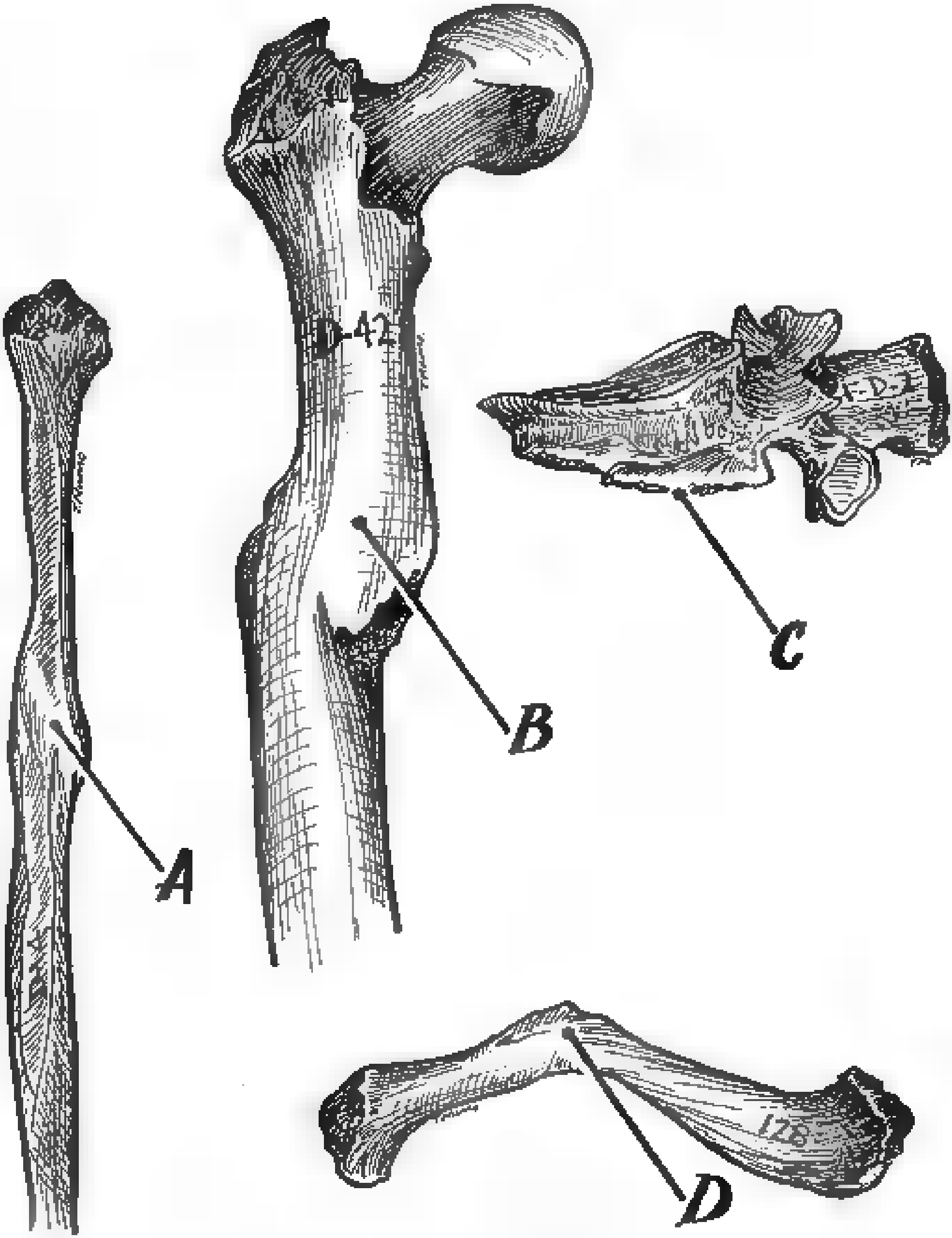

Figure 56

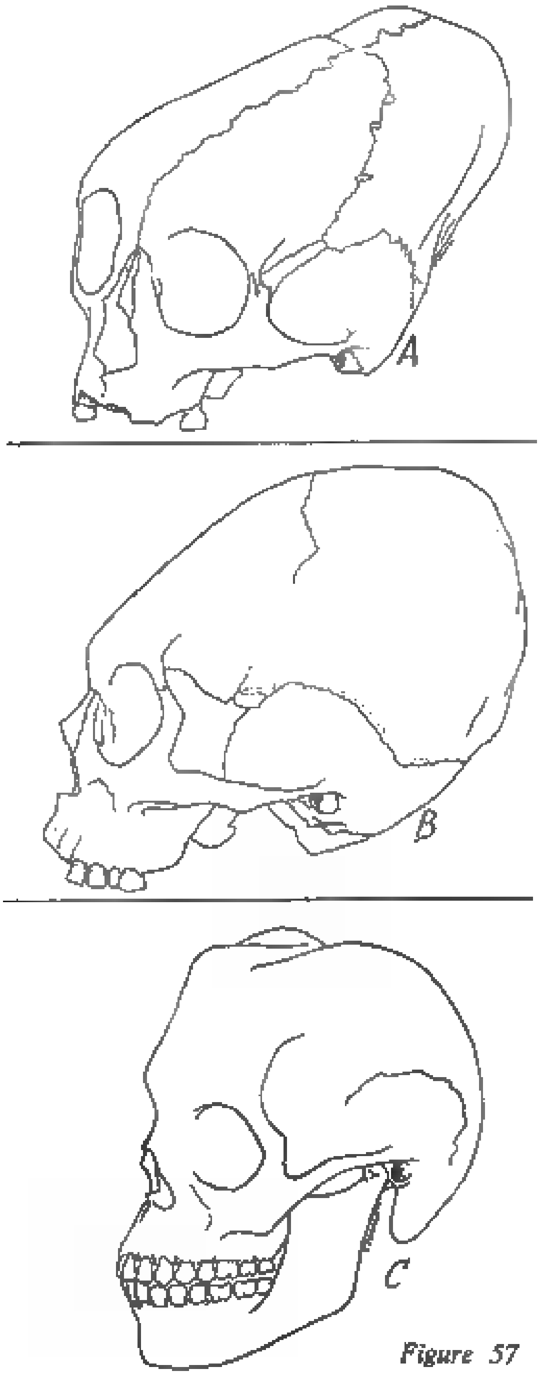

Figure 57

Cranial deformation may be produced naturally or artificially. The former is the result of premature closure of cranial sutures. The resulting shape of the skull depends on which sutures [redacted] involved.

Artificial head deformation was practised in certain areas of the world. Pressure was exerted on the head of the young through various types of binding. Illustrated in *Figure 57* [redacted] three types of artificial cranial deformation:

A. The annular type, which [redacted] produced by bandages wrapped in a circular manner around the head. As a result, the skull is elongated and coronally grooved.

B. Pressure applied to the frontal and occipital regions through binding to [redacted] flat structure, such [redacted] [redacted] cradle-board, results in [redacted] high skull compressed in the antero-posterior dimension.

C. A skull in which binding has produced [redacted] trilobed cranial vault.

Of considerable interest is evidence of trephining, the practice of drilling holes in bones, especially the skull. If the drilling is done during the life of the individual, signs of healing may be seen; if it is done at or after death, however, the edges of the drilled hole will be sharp. Four examples of trephined skulls are shown in *Figure 58*.

A. Four cuts have removed a square plug of bone.

B. A circular trephination, partially healed.

C. An elongated, scraped trephination.

D. A drilled circular hole just behind the bregma.

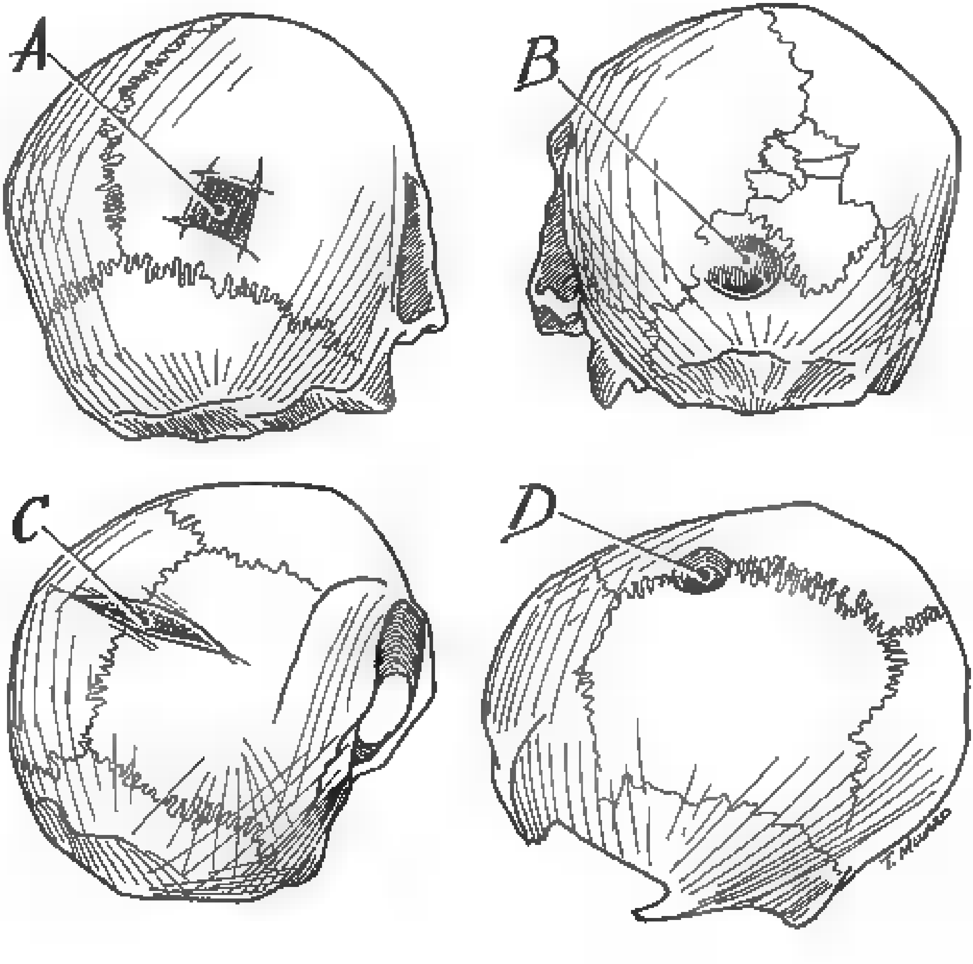

Figure 58

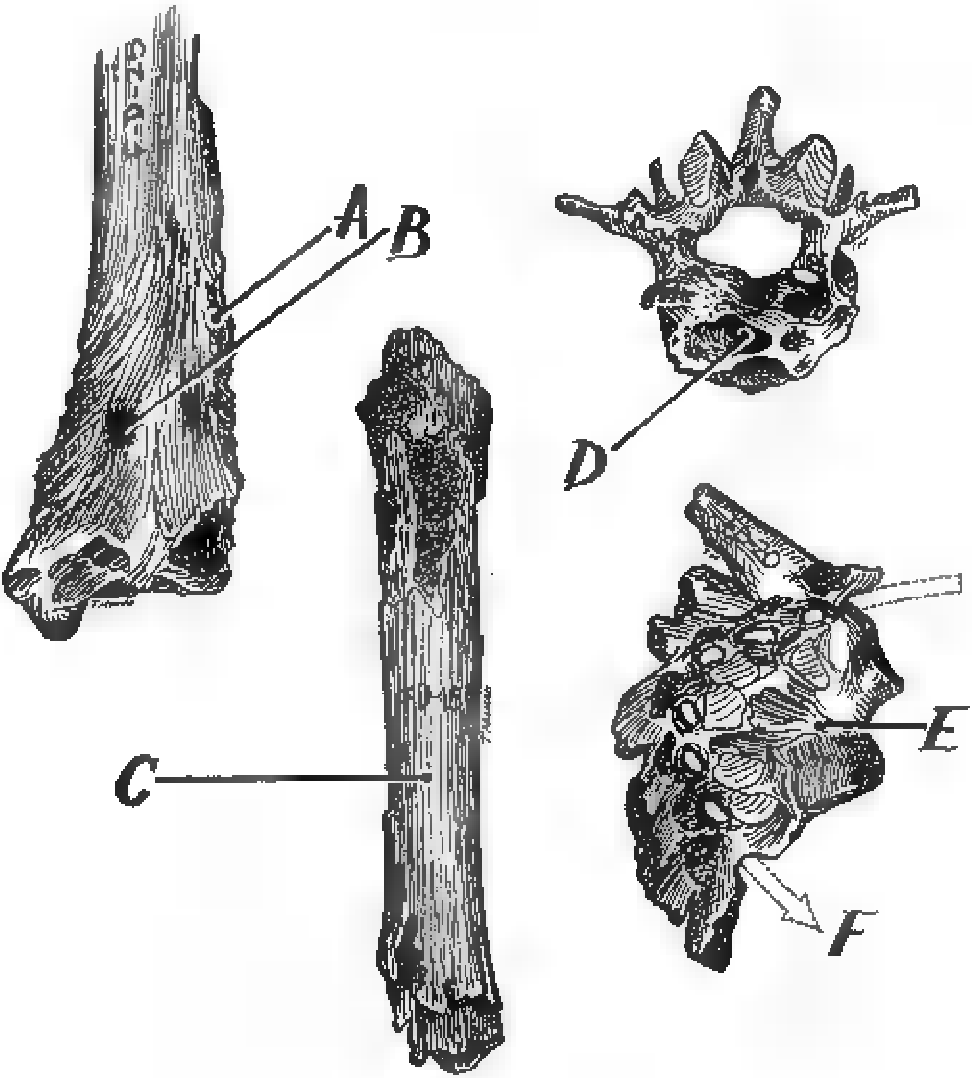

Figure 59

2. **Infections** of bone may leave permanent signs. Osteomyelitis in its various stages is seen in the skeletons of North American Indians. Tuberculosis and syphilis may also be seen, although the findings are not so specific [redacted] desired, and considerable doubt usually exists in making a definite diagnosis.

Osteomyelitis occurs when bacteria gain access to bone whether through extension of a local soft tissue infection, spread via the blood, or as [redacted] complication of a compound fracture. An abscess or collection of pus forms within the substance of bone.

Figure 59 illustrates examples of infection in bones. Note:

A. In this case of osteomyelitis of the tibia, there is an irregular increase in the width of the shaft because of [redacted] deposit of spongy-like bone. This is called the *involucrum*.

B. A hole called a *cloaca*, through which pus drains from the interior of the bone. Here the hole is single and large; sometimes the holes [redacted] multiple and small.

C. A piece of dead bone from the tibia resulting from massive infection. A fragment such [redacted] this is called [redacted] *sequestrum* and may be recognized by its lack of structure and the irregular margins of separation. Sequestra may be small splinters of bone, or large fragments [redacted] shown here.

D. Erosion of [redacted] vertebral body, producing [redacted] "swiss cheese" appearance.

E. Further extension of the disease may result in collapse of the vertebral bodies, so producing [redacted] posterior bowing of the spine. Healing has occurred with fusion of adjacent areas of bone.

F. Note the now markedly curved vertebral canal for the spinal cord.

3. TUMOURS of bone are rarely seen. They may appear [redacted] swellings distorting the normal bone contours, or [redacted] punched-out or eaten-away areas. Some examples from post mortem specimens are shown in *Figure 60*.

A. *Cancer* has spread from the lung and invaded bone, producing this eroded [redacted] on the vault of the skull.

B. An *auditory exostosis,* a tiny growth of new bone into the external auditory canal.

C. A case of *multiple myeloma,* where the bone of the skull vault has been replaced by softer tumour tissue.

D. Secondary cancer invading the humerus producing [redacted] fungus-like growth of new bone. A fracture has occurred at the site.

4. DEFICIENCY DISEASES. Rickets is due to [redacted] deficiency of calcium occurring in infancy and early childhood. The shortage of calcium during the formative period results in the softening of the bone and the bending of the skeleton under the weight of the individual. There is bowing of long bones, curvature of the vertebral column, forward displacement of the sternum to produce "pigeon breast," bossing of the skull in the frontal and parietal region resulting in a box-like cranium, and the formation of lumps on the ribs at the junction of bone and costal cartilage.

A rarefaction of the bone, given the name of symmetrical osteoporosis, has been reported in Indian skeletons from various sites. It is tentatively ascribed to a vitamin deficiency.

5. DEGENERATIVE CHANGES of the skeleton [redacted] seen in osteoarthritis, which is perhaps a normal ageing process, called a disease if it progresses [redacted] degree that it produces clinical symptoms. Degeneration of bone follows after destruction of the softer tissues of the joint. It is seen most frequently in hip, knee, and finger joints, and on vertebral bodies.

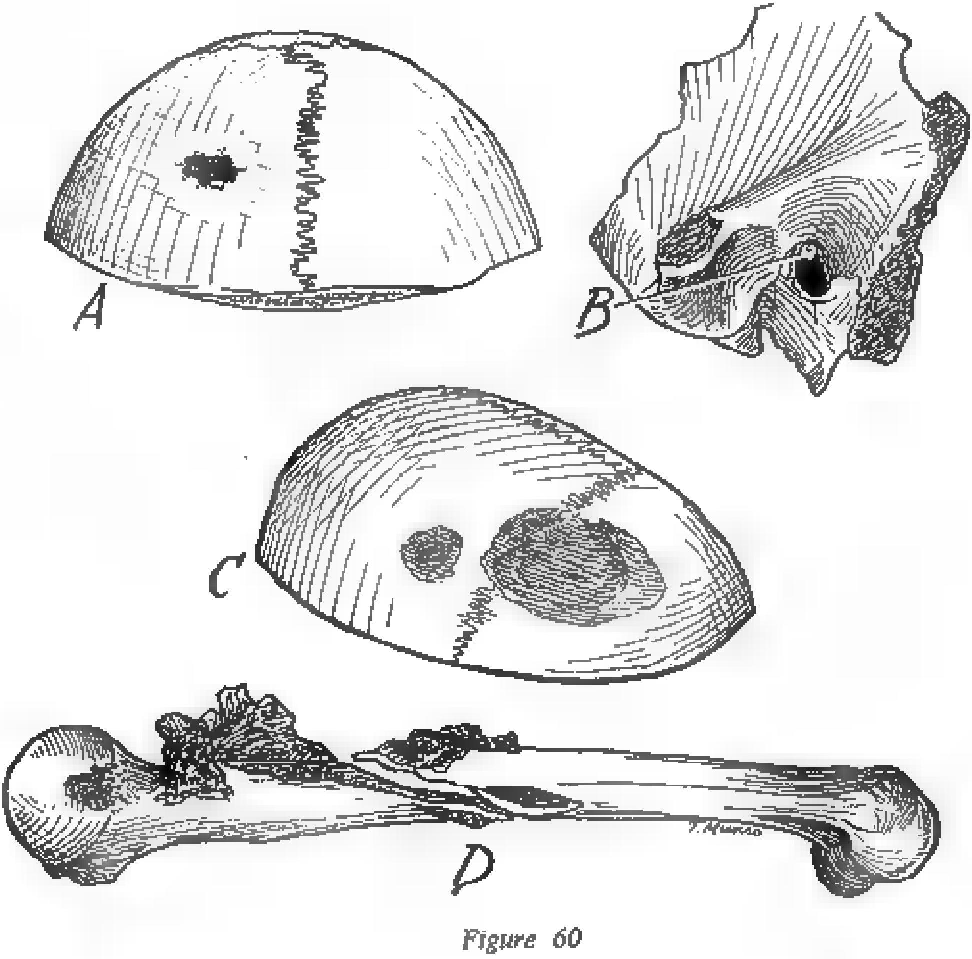

Figure 60

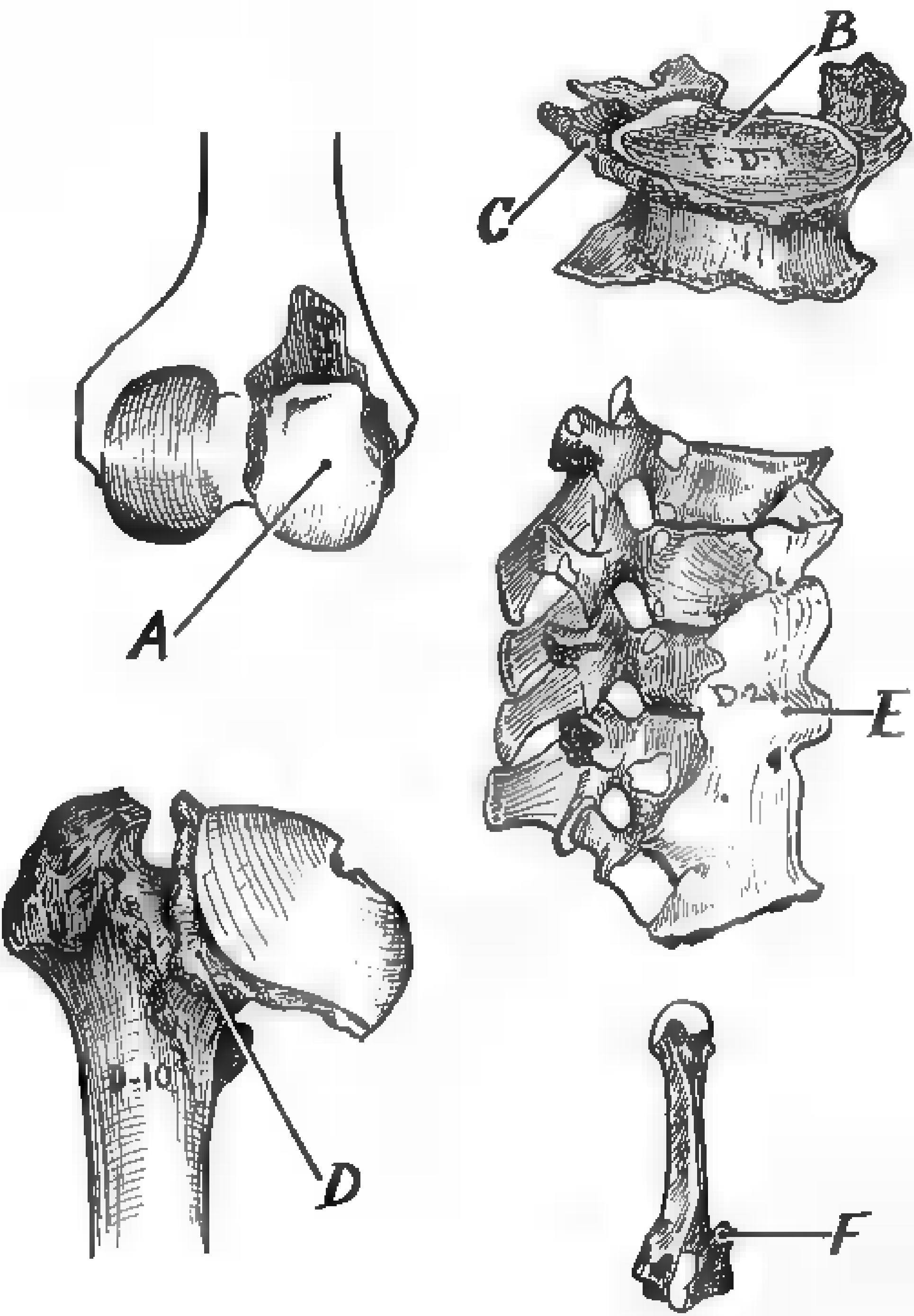

Figure 61

Some manifestations of osteoarthritis are illustrated in *Figure 61:*

A. The articular surface undergoes a curious process of condensation and hardening, until it becomes polished like ivory. This process is known as *eburnation* and is seen here on a femoral condyle.

B. While central parts of bone become rarefied (osteoporosis),

C. there is a peripheral growth of new bone, produced along the margin of the articular surface. This is known as *lipping*.

D. Lipping may become extremely marked, producing disruption of joint, as seen here in the distorted proximal end of the femur.

E. In this specimen, adjacent parts of the vertebral column have fused. Notice how ossification on the anterior part of the bodies resembles candle wax drippings.

F. Little bony spurs may grow out, called *osteophytes*, illustrated here on a phalanx.

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CHAPTER XVIII

RECONSTRUCTING THE POPULATION

This chapter outlines three aspects of a population that may be reconstructed from study of the skeleton:

A. Burial practices
B. Vital statistics
C. Physical subtypes

A. BURIAL PRACTICES

The burial practices of a population may be classified in the following simple manner:

FORM OF BURIAL—

1. *Individual*, (*a*) *Articulated*—a primary burial in which the parts of the skeleton lie in the same anatomical relationship to each other that they had in life. This form suggests that the individual had been buried intact in the grave and had become reduced to a skeleton *in situ*.

   (*b*) *Bundle*—a secondary burial in which the parts of an individual had been gathered together, perhaps after primary burial elsewhere. The bones are not arranged in their normal anatomical relationship to each other.

2. *Multiple*, (*a*) *Ossuary*—a grave in which numbers of individuals are represented, but where their parts are so scattered that discrete skeletons may not be recognized.

   (*b*) *Pattern*—the bones of a number of individuals are in a common grave, arranged in a ritualistic pattern.

Position of the Skeleton—

1. The *relationship* of the segments of the body to each other. The skeleton may be lying so that the limbs [redacted] *flexed* (bent), or *extended* (straight), or a combination of the two.
2. The *orientation* of the body to the grave. The skeleton may have been buried lying on its back, on one side, face down, or in the sitting position.
3. Compass *direction* of the orientation of the body in the grave.

Type of Grave—

1. *Pit.* The skeleton lies below the surface of the ground in an excavation which has been filled in.
2. *Mound.* Burial occurred above the surface of the ground, surrounded by a pile of earth.
3. *Cist.* The skeleton lies in a grave with stone walls.
4. *Rock cairn.* Rocks were piled over [redacted] surface burial.

Practices—

1. The inclusion of grave goods.
2. Evidences of cremation.
3. The presence of red ochre in the grave.
4. Signs of mutilation: loss of limbs, replacement with animal parts, inclusion of parts of other human skeletons.

B. VITAL STATISTICS

In the evaluation of a site, the archaeologist looks to the skeletal evidence for clues to the size of the population, its age and sex proportion, and its mortality rate. Of particular interest is the maternal and infant mortality rate and the incidence of diseases that leave their signs on bone. The basic data for these conclusions come from an inventory of the number of individuals represented in the cemetery and their age and sex distribution.

Deriving this information from discrete *individual burials* is relatively simple when the full skeleton is available for study. There [redacted] [redacted] few problems, however. It must be certain that all skeletons are recovered, care being taken that there is no loss of infant material, poorly preserved bone, and fragmentary burials. The determination of sex and age from the skeleton is [redacted] difficult task at best, and so it is important that as much information as possible is available for study by the physical anthropologist.

1. In young individuals, the determination of age may be greatly assisted by observing and recording in the field the state of ossification of the skeleton. The secondary centres of ossification are readily examined *in situ;* however they are meaningless bits of bone if merely collected and put in a specimen bag. *Figure 62* is a schematic diagram of a young burial, pointing out key areas to be inspected and recorded in the field notes.

2. Certain parts of the skeleton are of more value than others for the calculation of vital statistics. They require special [redacted] in excavation, reconstruction, preservation, and packing for shipment. Notable are the teeth, particularly in the formative stage, when they are readily lost from their crypts in the bone. The symphysis pubis, almost always broken away from the rest of the pelvis, deserves special attention and protection of its surface which is of great value in age determination.

In the case of *mass burials* where there is no possibility of identifying discrete individuals, the difficulties [redacted] more numerous. All the material must be collected, no matter how fragmentary. It is then sorted into the various bones of the skeleton. The fragments [redacted] grouped into right and left, proximal and distal ends. After as much reconstruction as possible has been done, an inventory of each type of bone is made. For estimation of the number of individuals, certain bones are more useful than others: the temporal bone, which is the most durable element of the skull; the femur, which is large and strong; the axis, which is a distinctive vertebra; and the talus. This inventory gives a minimum number for individuals represented.

The bones are next separated into mature and immature. Parts of the young skeleton are ranked according to size and state of fusion of their secondary centres to determine age distribution in the sample. Sex determination may be done on crania with perhaps 90 per cent accuracy. As far as the infracranial skeleton is concerned, the measurement of size, diameter of articular surfaces, and general robustness of the muscle markings may be used to sort the bones into presumptive male and female categories. It is noteworthy that quantitative standards for [redacted] determination derived from White or Negro material are not directly referable to

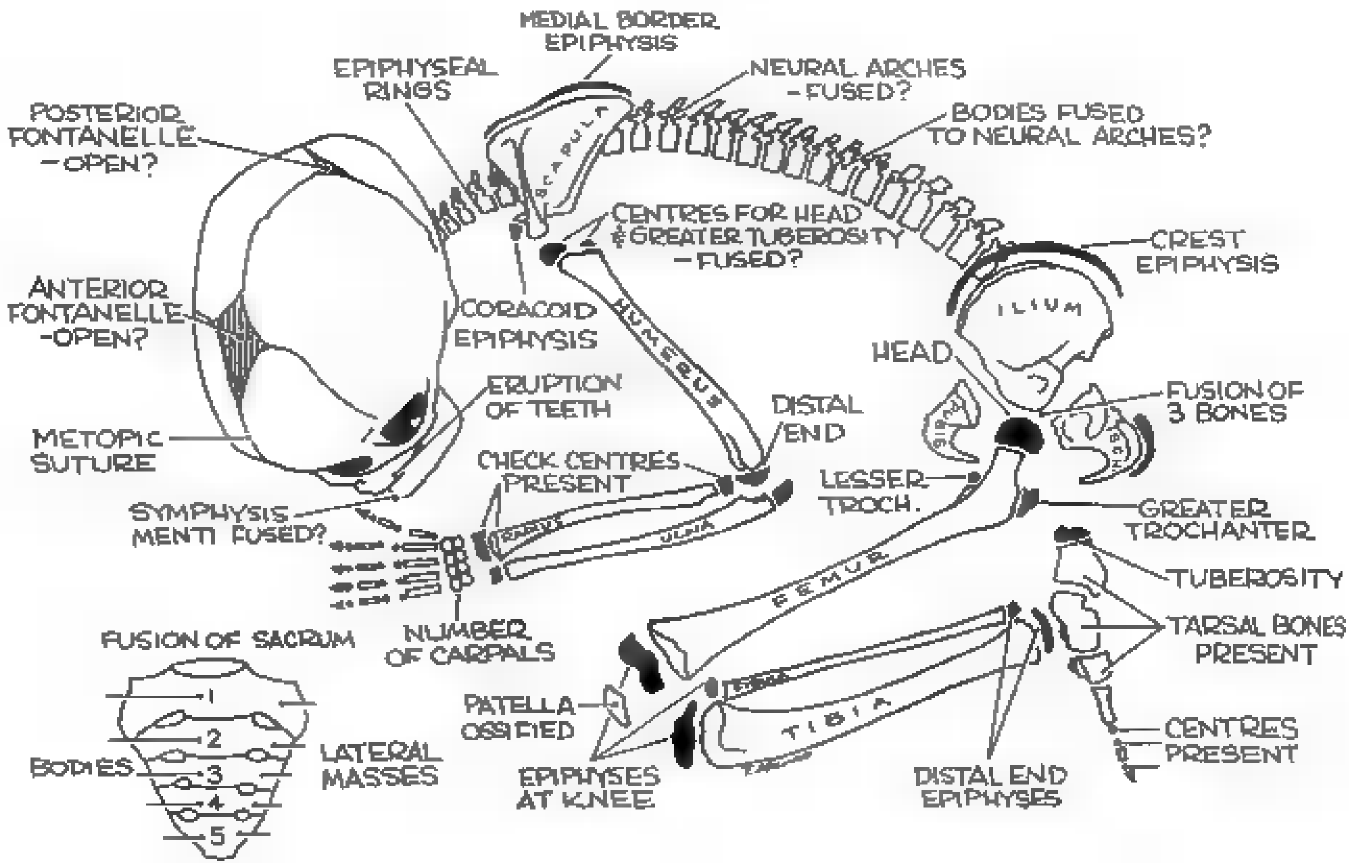
MEDIAL BORDER EPIPHYSIS
EPIPHYSEAL RINGS
NEURAL ARCHES - FUSED?
BODIES FUSED TO NEURAL ARCHES?
POSTERIOR FONTANELLE - OPEN?
SCAPULA
CENTRES FOR HEAD & GREATER TUBEROSITY - FUSED?
CREST EPIPHYSIS
ILIUM
ANTERIOR FONTANELLE -OPEN?
CORACOID EPIPHYSIS
HUMERUS
HEAD
ERUPTION OF TEETH
DISTAL END
FUSION OF 3 BONES
METOPIC SUTURE
CHECK CENTRES PRESENT
LESSER TROCH.
SYMPHYSIS MENTI FUSED?
RADIUS
ULNA
GREATER TROCHANTER
TUBEROSITY
FEMUR
FUSION OF SACRUM
NUMBER OF CARPALS
TARSAL BONES PRESENT
1
2
3
4
5
BODIES
LATERAL MASSES
PATELLA OSSIFIED
TIBIA
CENTRES PRESENT
EPIPHYSES AT KNEE
DISTAL END EPIPHYSES

Figure 62

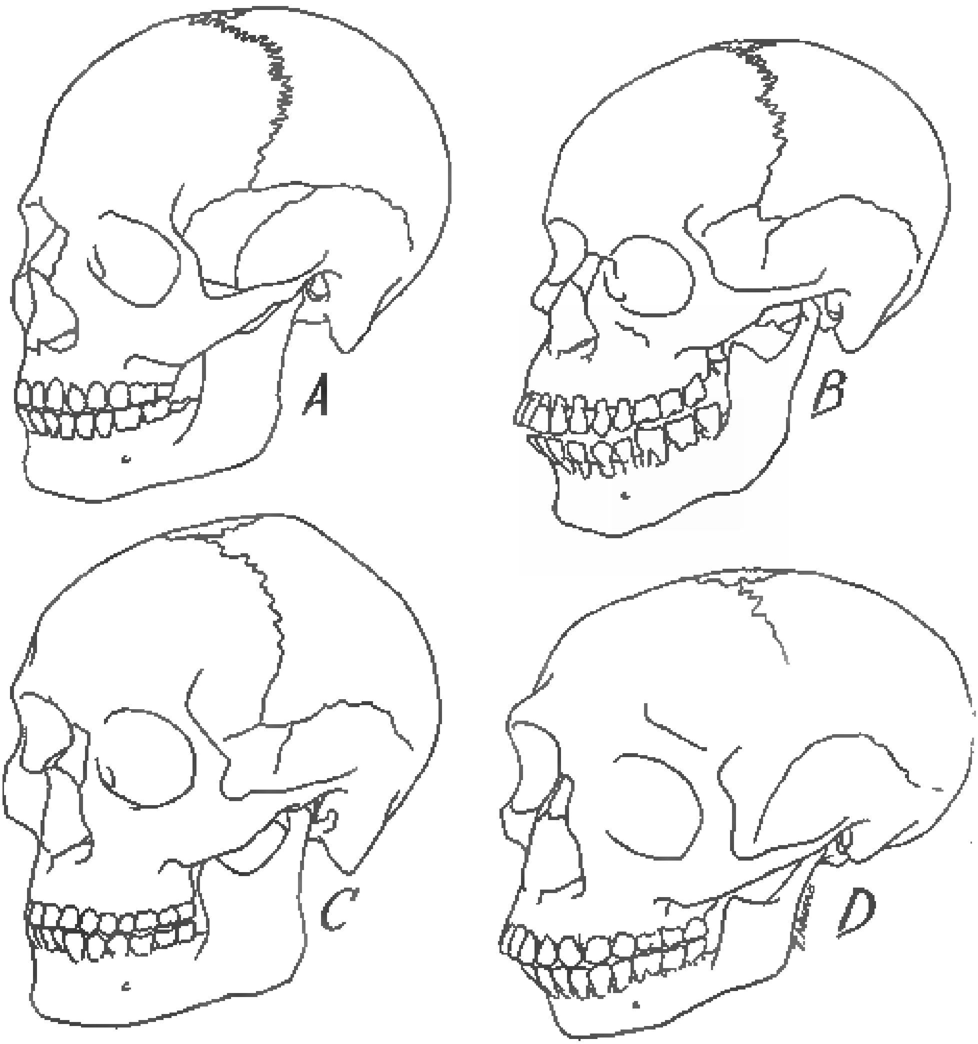

Figure 63

an Indian population. Our estimates based [redacted] existing information constitute only an educated guess.

Converting the burial information into vital statistics of the population involved, depends for its validity upon the answers to the following questions:

1. Does the cemetery represent all the individuals dying on one site? Is there more than one cemetery? Is this a selective burial area restricted to individuals of a certain social status, age, or sex group? Was it used only at certain times of the year? Is there a missing segment of the population such as warriors who might die and be buried away from the village, or infants who may have unceremonial burial in some other area?
2. Does the cemetery contain one population only? The possibility of foreign burials of visitors, prisoners, and adopted members of the group should be considered, as well as later burials intrusive into [redacted] old cemetery. The presence of these "foreign" burials will certainly affect both the numerical value of population studies and the evaluation of morphological types.
3. What is the temporal duration of the use of the cemetery?

In summary, it may be stated that the value of the vital statistics derived from a burial area depends on meticulous excavation, careful field records, and a thoughtful consideration of the many factors which can invalidate results. Unless positive answers can be given to the questions asked, the figures derived should be accepted very cautiously.

C. PHYSICAL SUBTYPES

As the individuals of one population [redacted] studied, we tend to concern ourselves with similarities and differences in their appearance. Judgments are based on criteria of stature, build, proportion, cranial form, and the incidence of anomalies. It is difficult to decide which are the significant characteristics of [redacted] group of individuals that justify lumping them together [redacted] a physical subtype.

Four skulls are illustrated in *Figure 63*. These constitute four extremes of living human physical types.

A. A Caucasoid
B. An American Negro
C. A Plains Indian, one form of New World Mongoloid
D. An Australoid

The marked differences between these four skulls are obvious. However, they are selected from larger groups of populations which show great variation, but whose characteristics blend with each other.

Numerous attempts have been made to classify New World Mongoloids into physical subtypes. One of these is the system of Neumann (1952), who postulates eight subtypes of North American Indians based on shared morphological characters.

Before more adequate classification is possible, further study is required regarding—

1. Regional physical subtypes and their relationship in time.
2. The plasticity of morphological characteristics and the influences responsible for changes.
3. The genetic basis for anomalies and variations.

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